	Type	Hits	Search Text
1	BRS	219	370/338.ccls.
2	BRS	314	370/349.ccls.
3	BRS	582	370/389.ccls.
4	BRS	441	370/392.ccls.
5	BRS	381	370/400.ccls.
6	BRS	838	370/401.ccls.
7	BRS	1780	370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.
8	BRS	2439	(370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.
9	BRS	11944	rout$ with (packet or frame)
10	BRS	1266	((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))
11	BRS	27769	wireless
12	BRS	237	(((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))) and wireless
13	BRS	95148	hub
14	BRS	237	((((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))) and wireless) and ((((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))) and wireless)
15	BRS	4839	access adj (node or point)

370/338, 401
408,

please go thru one subclass at a time
370/338, 339,
to find better ref's.

Thank you

	Type	Hits	Search Text
16	BRS	66	(access adj (node or point)) and (((((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))) and wireless) and ((((370/338.ccls. or 370/349.ccls. or 370/389.ccls. or 370/392.ccls. or 370/400.ccls.) or 370/401.ccls.) and (rout$ with (packet or frame))) and wireless))

455/402, 572

340/310.01

~~6140,911~~

US006137797A

United States Patent [19]

Bass et al.

[11] **Patent Number: 6,137,797**

[45] **Date of Patent: *Oct. 24, 2000**

[54] **PROCESS DEFINITION FOR SOURCE ROUTE SWITCHING**

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[73] Assignee: **International Business Machines Corporation**, Armonk, N.Y.

[*] Notice: This patent issued on a continued prosecution application filed under 37 CFR 1.53(d), and is subject to the twenty year patent term provisions of 35 U.S.C. 154(a)(2).

[21] Appl. No.: **08/757,867**

[22] Filed: **Nov. 27, 1996**

[51] **Int. Cl.**[7] **H04J 12/28**; H04J 12/46

[52] **U.S. Cl.** **370/392**; 370/405; 370/423

[58] **Field of Search** 370/389, 390, 370/400, 401, 402, 403, 404, 405, 406, 407, 465, 467, 470, 392, 422, 423, 424, 425; 395/200.75, 200.79, 200.8, 200.81, 200.82, 200.83; 709/245, 249, 250, 251, 252, 253

[56] **References Cited**

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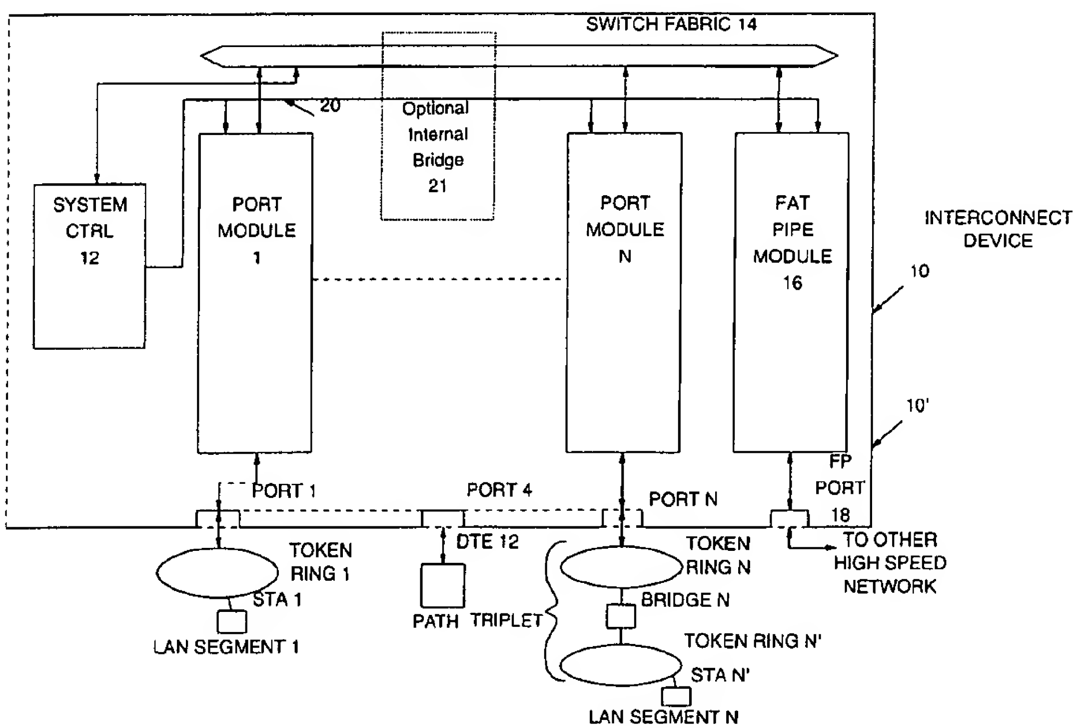
Primary Examiner—Chi H. Pham
Assistant Examiner—Kwang B Yao
Attorney, Agent, or Firm—Joscelyn G. Cockburn

[57] **ABSTRACT**

A device for interconnecting Local Area Networks (LANs) includes ports for attaching LAN segments and port modules for connecting the ports to a switch fabric. Each of the port modules include a mechanism which searches the Routing Information (RI) field of a Received frame to detect at least two Triplets (a minimum configuration for a LAN segment) indicating a Source path from an originator user and a Destination path to a destination user. The Triplet (single or in combination) is used to access a database (tables) which identifies the Port of Exit (POE) through which the frame is to be routed.

14 Claims, 13 Drawing Sheets



02/08/2002, EAST Version: 1.02.0008

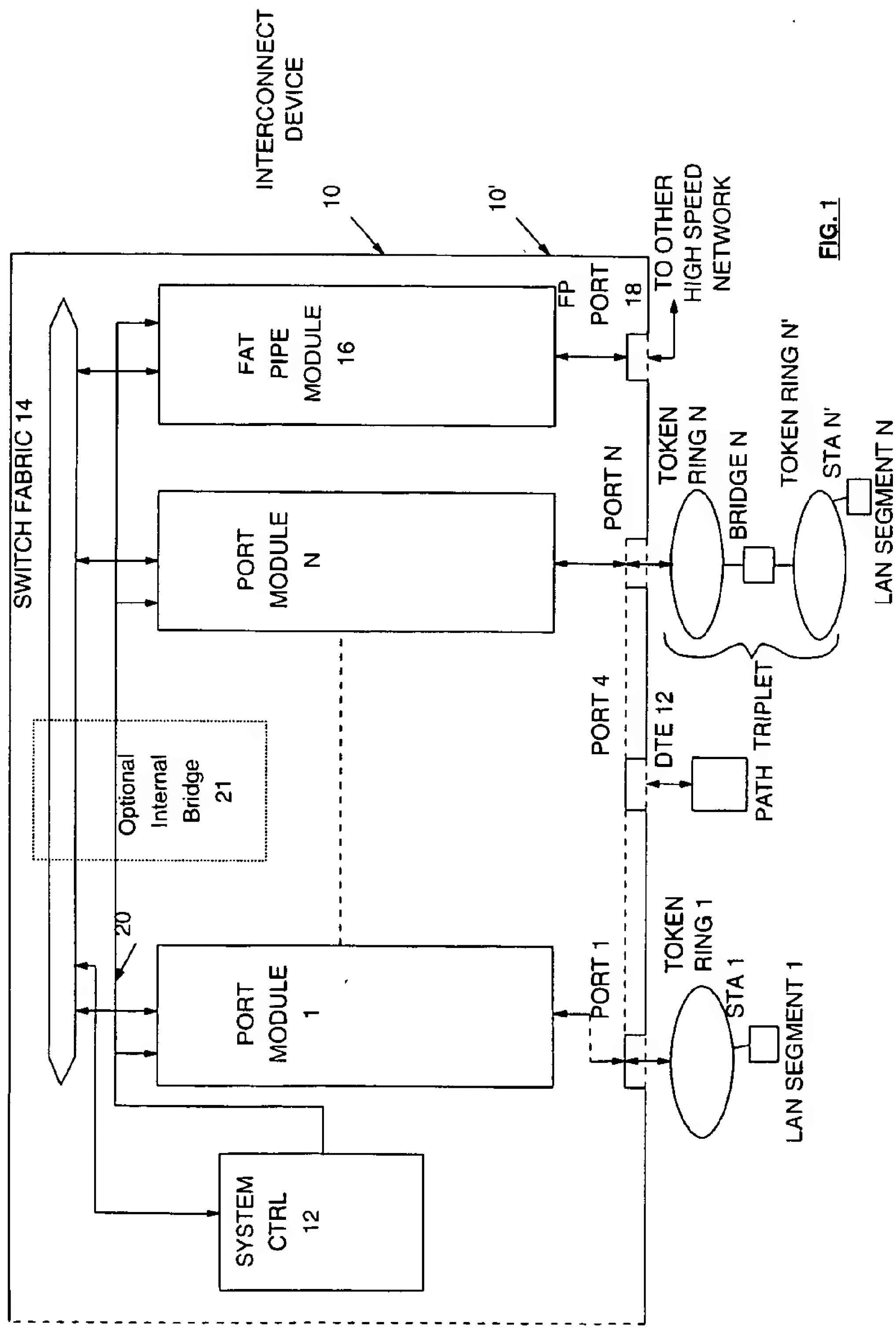

INTERCONNECT DEVICE
10
10'
SWITCH FABRIC 14
FAT PIPE MODULE 16
FP PORT 18
TO OTHER HIGH SPEED NETWORK
PORT MODULE N
PORT N
TOKEN RING N
BRIDGE N
TOKEN RING N'
STA N'
LAN SEGMENT N
TRIPLET
Optional Internal Bridge 21
PORT 4
DTE 12
PATH
20
PORT MODULE 1
PORT 1
TOKEN RING 1
STA 1
LAN SEGMENT 1
SYSTEM CTRL 12

FIG. 1

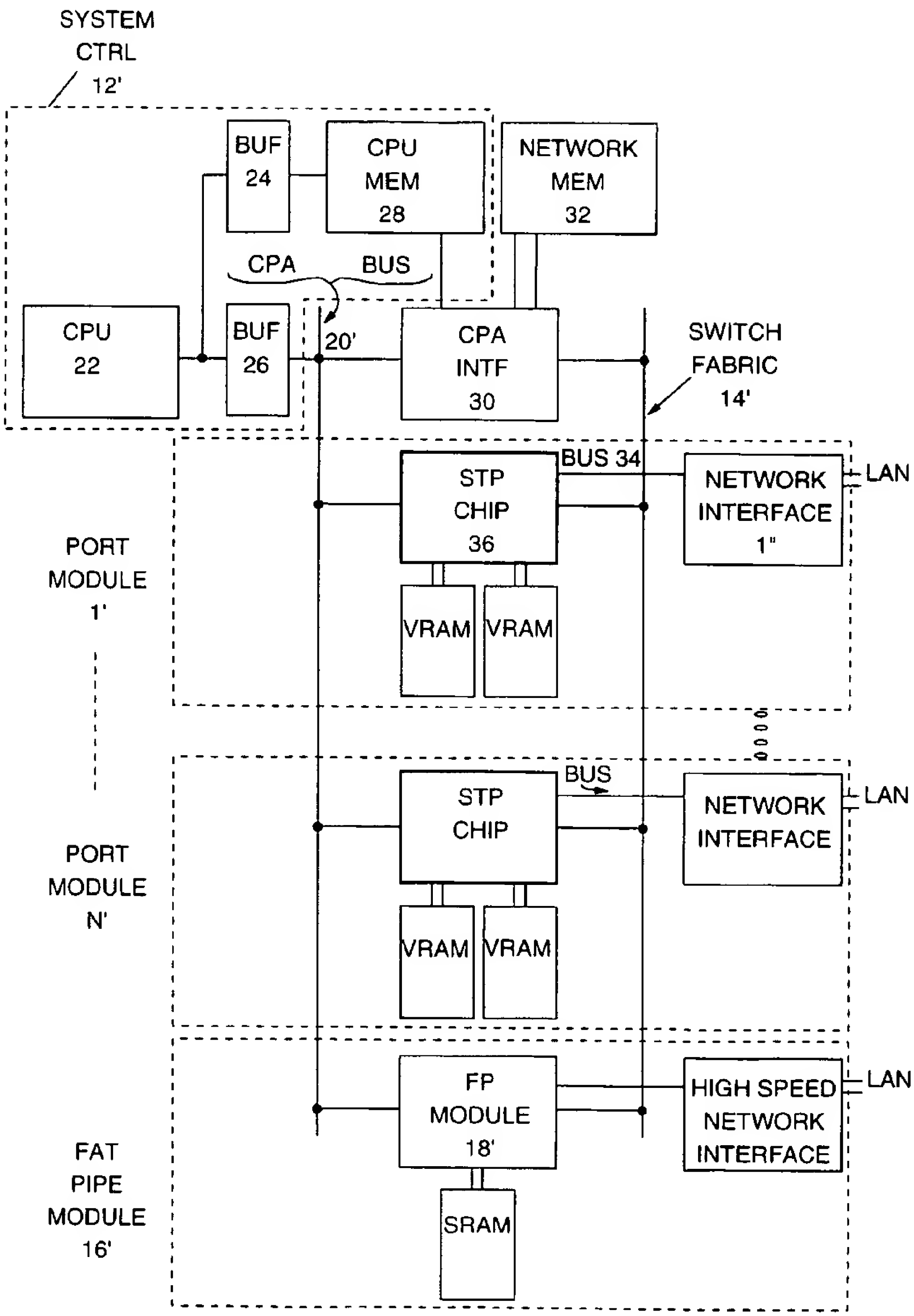

SYSTEM
CTRL
12'
BUF
24
CPU
MEM
28
NETWORK
MEM
32
CPA
BUS
CPU
22
BUF
26
20'
CPA
INTF
30
SWITCH
FABRIC
14'
BUS 34
STP
CHIP
36
NETWORK
INTERFACE
1"
LAN
PORT
MODULE
1'
VRAM
VRAM
BUS
STP
CHIP
NETWORK
INTERFACE
LAN
PORT
MODULE
N'
VRAM
VRAM
FP
MODULE
18'
HIGH SPEED
NETWORK
INTERFACE
LAN
FAT
PIPE
MODULE
16'
SRAM

FIG. 2

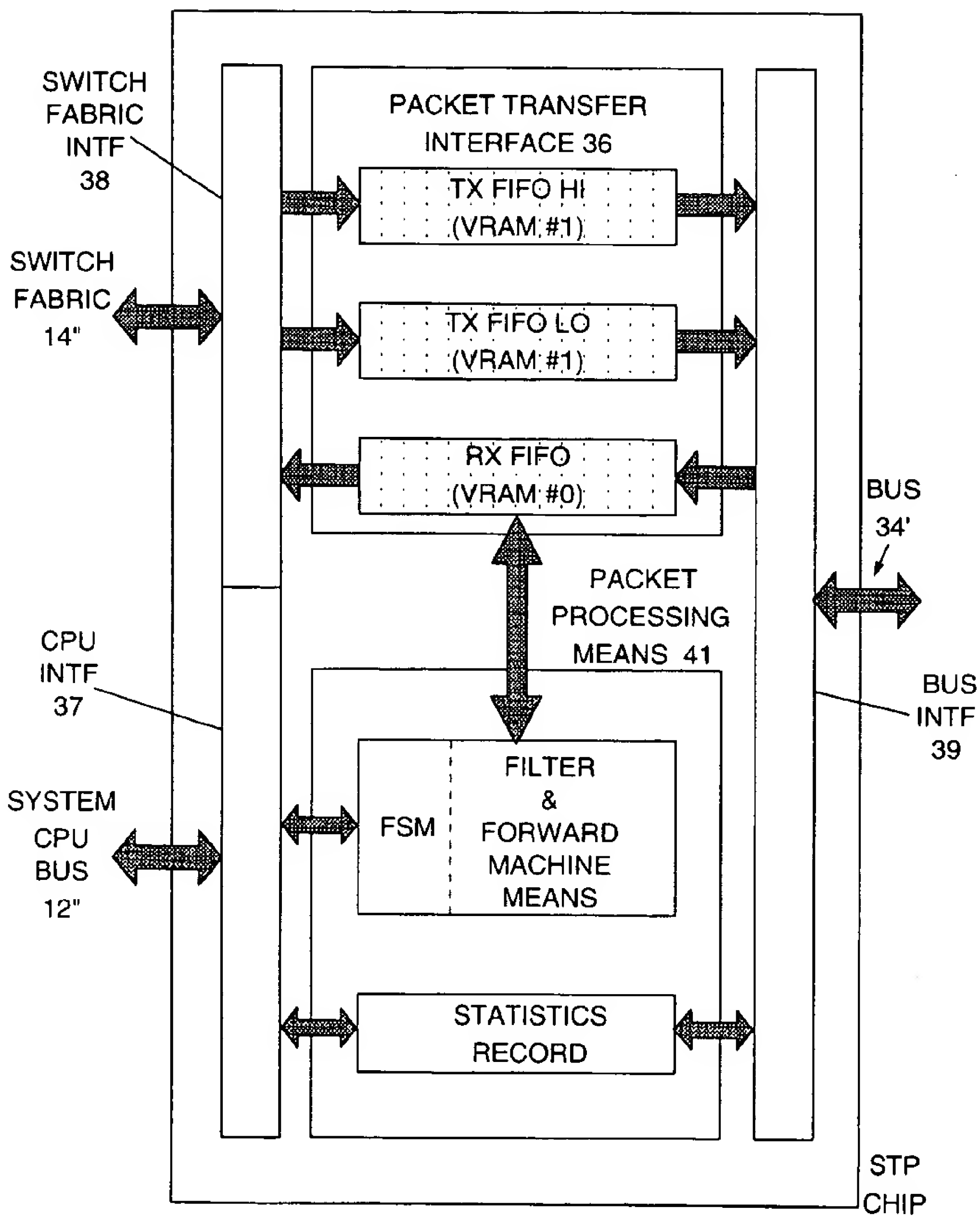
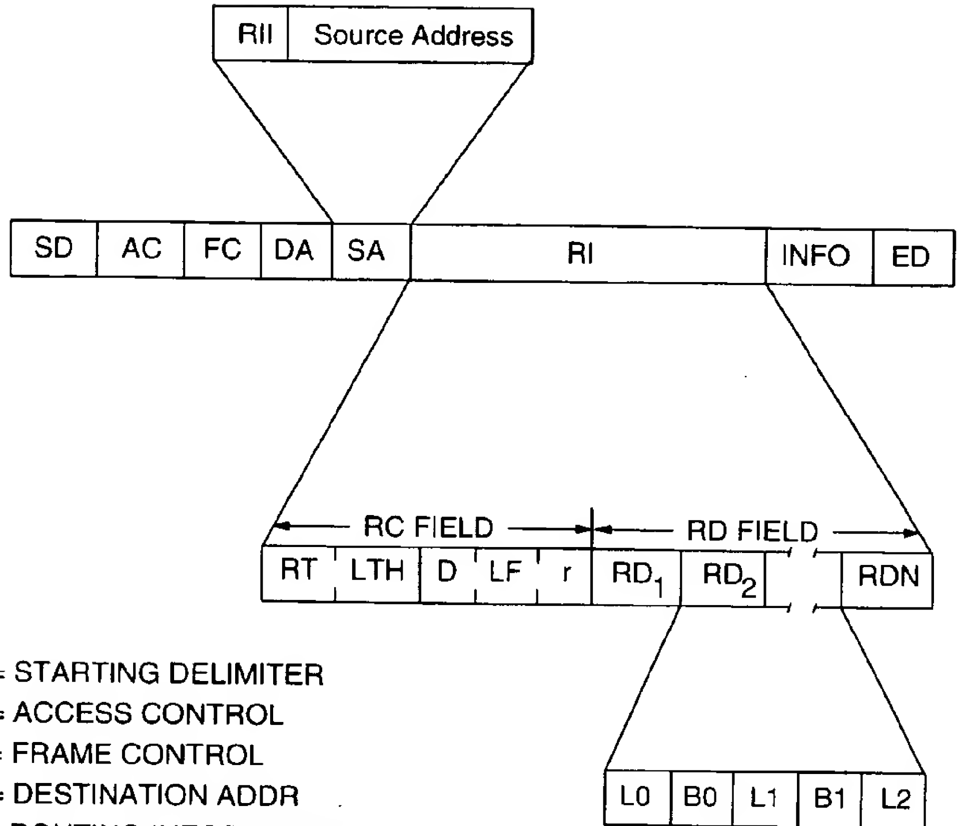

SWITCH FABRIC INTF 38
SWITCH FABRIC 14"
PACKET TRANSFER INTERFACE 36
TX FIFO HI (VRAM #1)
TX FIFO LO (VRAM #1)
RX FIFO (VRAM #0)
BUS 34'
PACKET PROCESSING MEANS 41
CPU INTF 37
BUS INTF 39
SYSTEM CPU BUS 12"
FSM
FILTER & FORWARD MACHINE MEANS
STATISTICS RECORD
STP CHIP

FIG. 3



SD = STARTING DELIMITER
AC = ACCESS CONTROL
FC = FRAME CONTROL
DA = DESTINATION ADDR
RII = ROUTING INFORMATION INDICATOR
SA = SOURCE ADDR
RI = ROUTING INFORMATION
RT = ROUTING TYPE
LTH = LENGTH FIELD
D = DIRECTION BIT
LF = LARGEST FRAME
r = RESERVE
RC = ROUTE CONTROL
RD = ROUTE DESCRIPTOR

FIG. 4

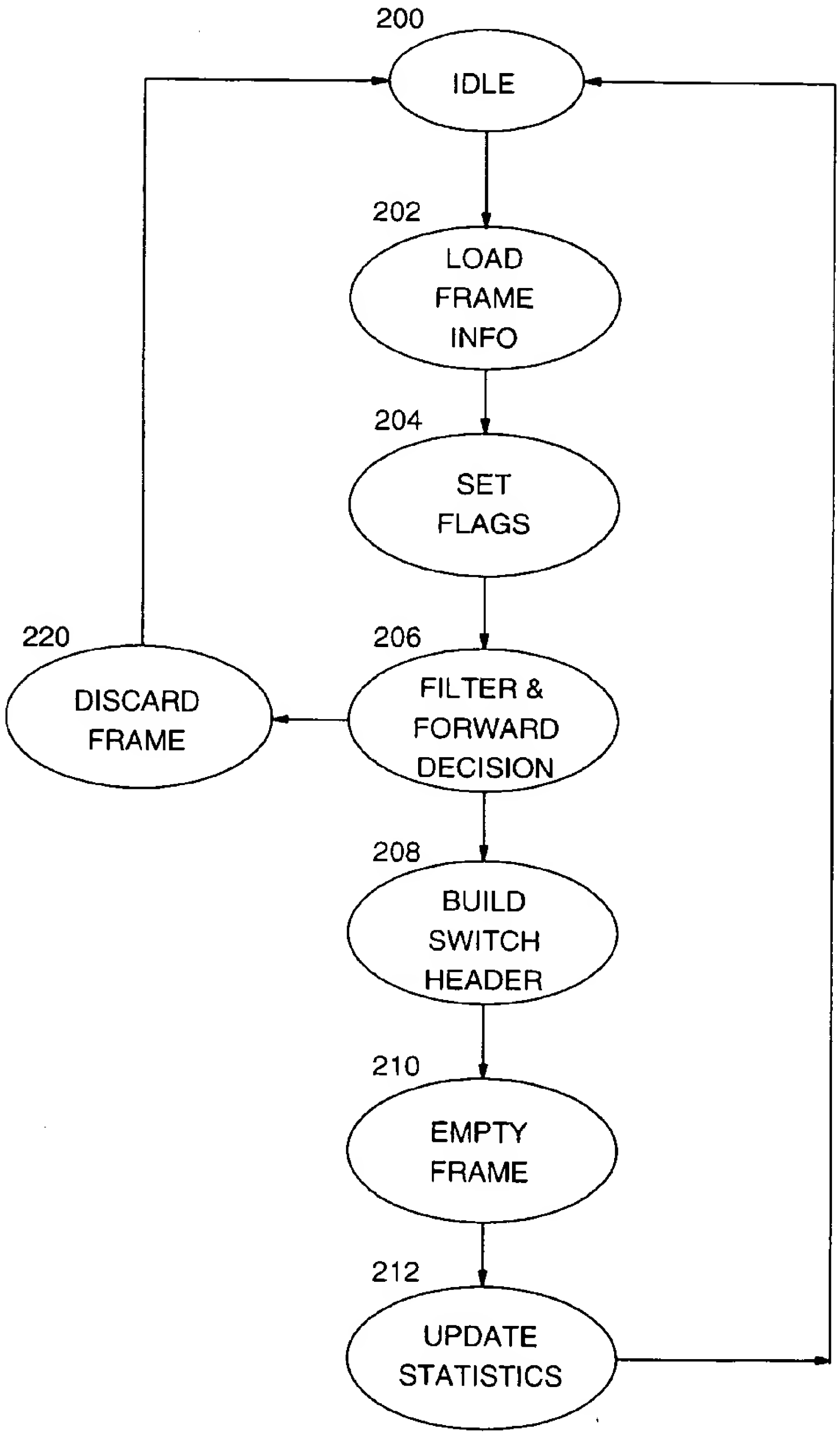

200
IDLE
202
LOAD FRAME INFO
204
SET FLAGS
206
FILTER & FORWARD DECISION
220
DISCARD FRAME
208
BUILD SWITCH HEADER
210
EMPTY FRAME
212
UPDATE STATISTICS

FIG. 5

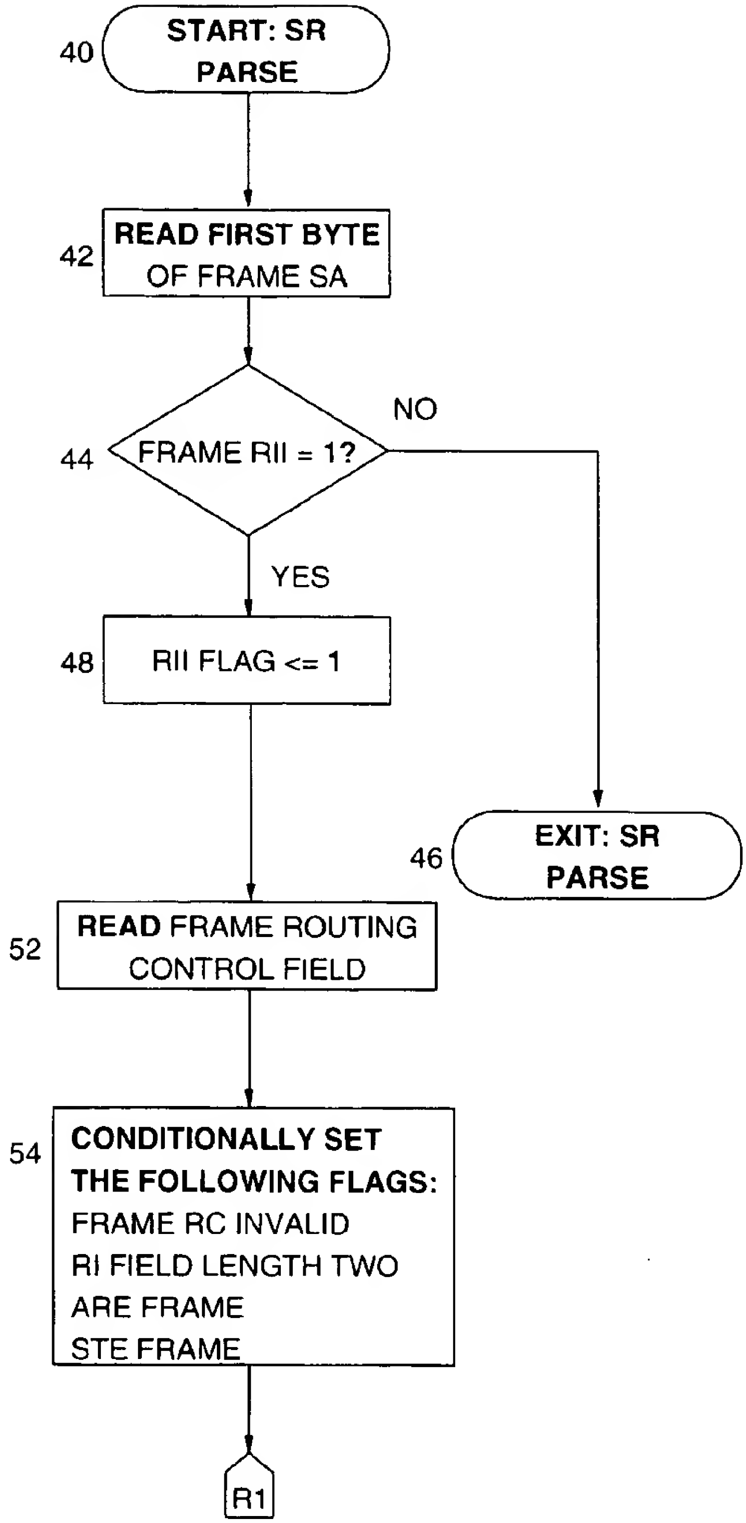

START: SR PARSE
40
READ FIRST BYTE OF FRAME SA
42
FRAME RII = 1?
44
NO
YES
RII FLAG <= 1
48
EXIT: SR PARSE
46
READ FRAME ROUTING CONTROL FIELD
52
CONDITIONALLY SET THE FOLLOWING FLAGS:
FRAME RC INVALID
RI FIELD LENGTH TWO
ARE FRAME
STE FRAME
54
R1

FIG. 6A

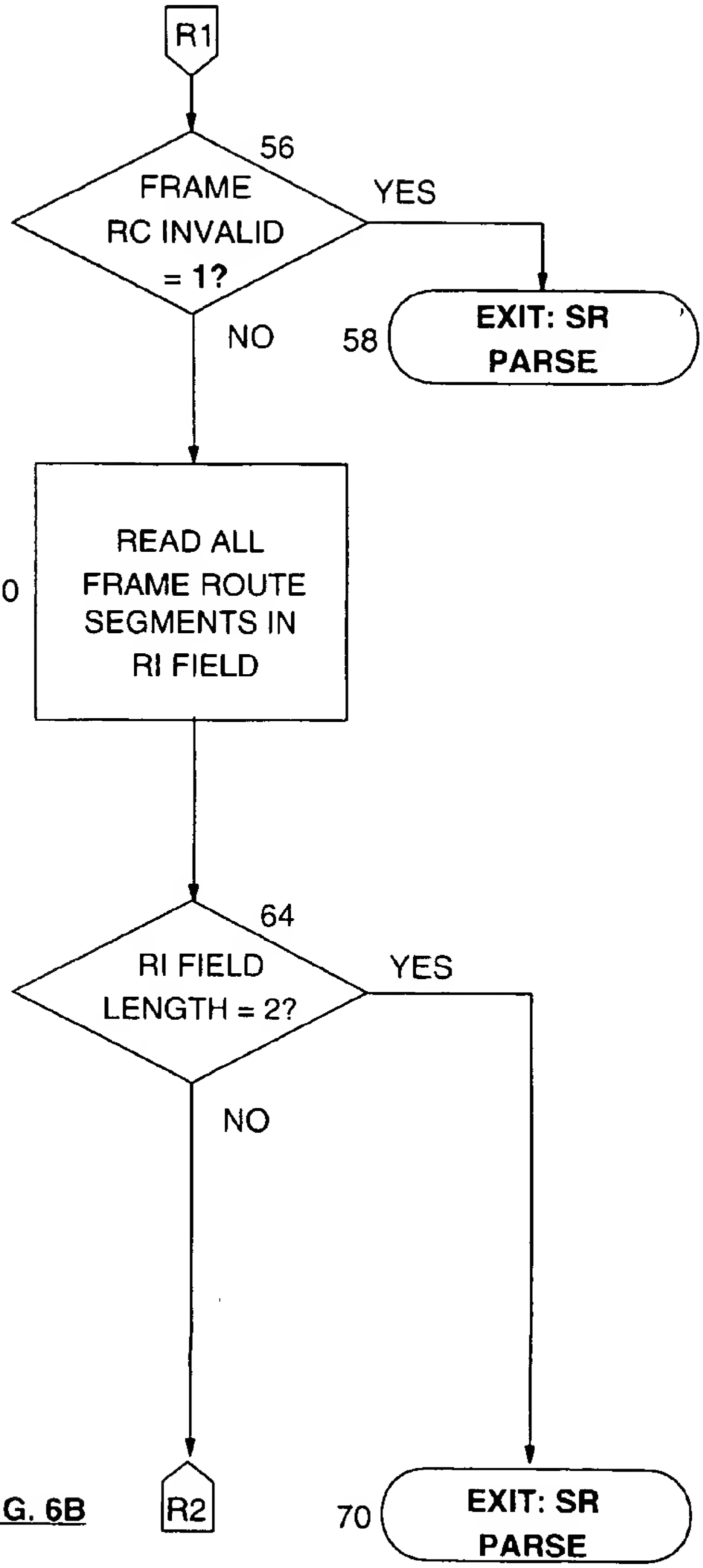

R1
56
FRAME
RC INVALID
= 1?
YES
NO
58
EXIT: SR
PARSE
60
READ ALL
FRAME ROUTE
SEGMENTS IN
RI FIELD
64
RI FIELD
LENGTH = 2?
YES
NO
R2
70
EXIT: SR
PARSE

FIG. 6B

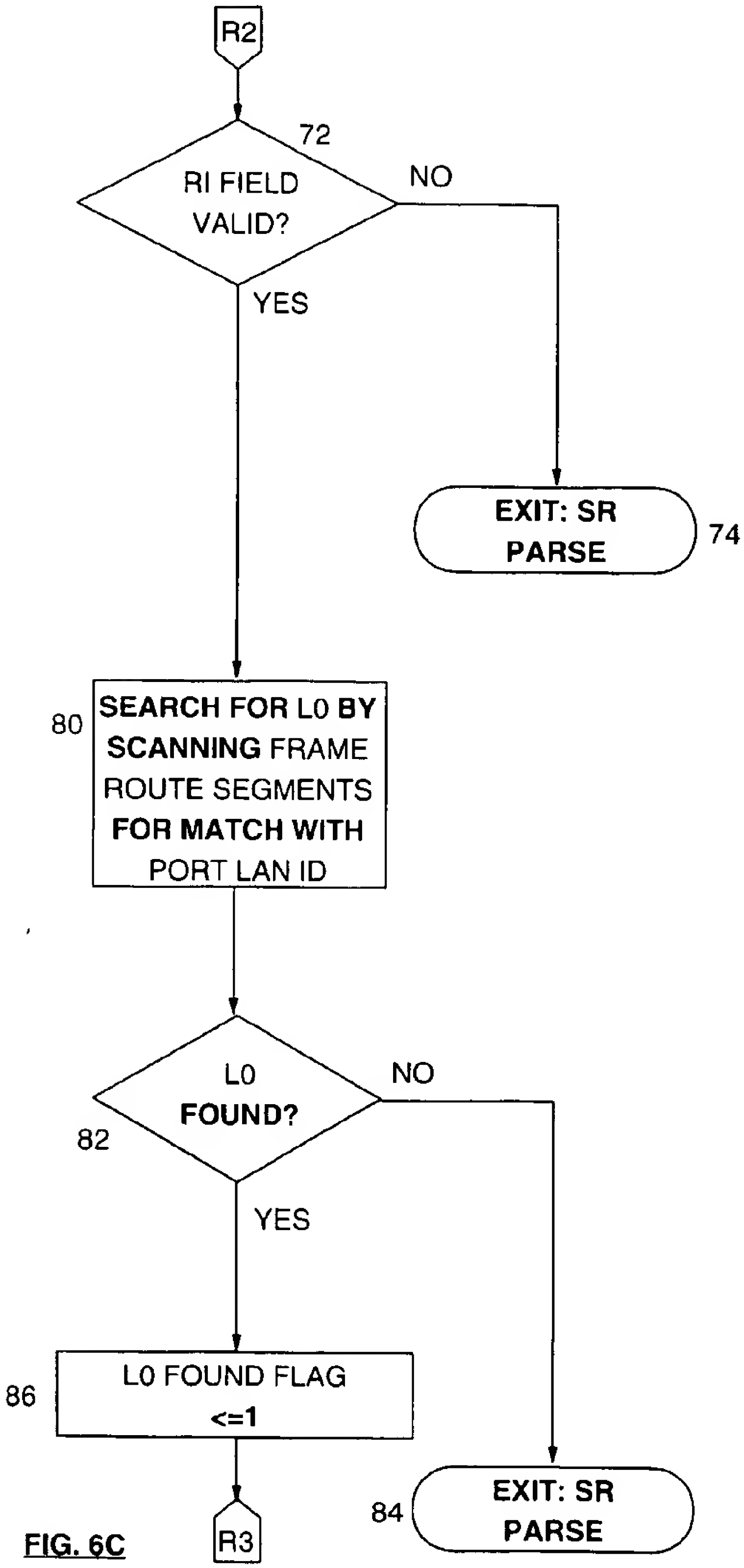

R2
72
RI FIELD VALID?
NO
YES
EXIT: SR PARSE
74
80
SEARCH FOR L0 BY SCANNING FRAME ROUTE SEGMENTS FOR MATCH WITH PORT LAN ID
L0 FOUND?
82
NO
YES
86
L0 FOUND FLAG <=1
R3
84
EXIT: SR PARSE

FIG. 6C

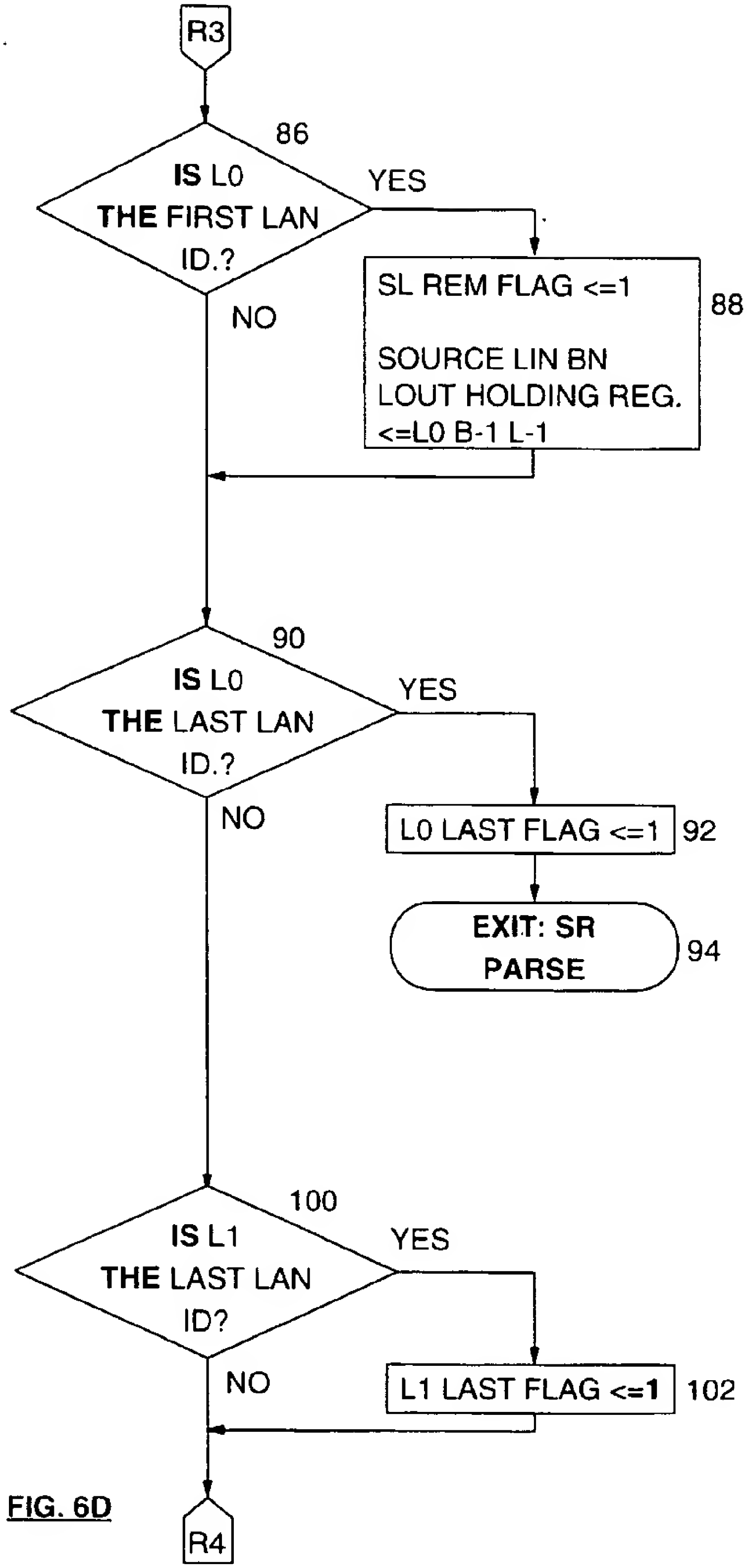

R3
86
IS L0
THE FIRST LAN
ID.?
YES
NO
SL REM FLAG <=1
SOURCE LIN BN
LOUT HOLDING REG.
<=L0 B-1 L-1
88
90
IS L0
THE LAST LAN
ID.?
YES
NO
L0 LAST FLAG <=1
92
EXIT: SR
PARSE
94
100
IS L1
THE LAST LAN
ID?
YES
NO
L1 LAST FLAG <=1
102
R4

FIG. 6D

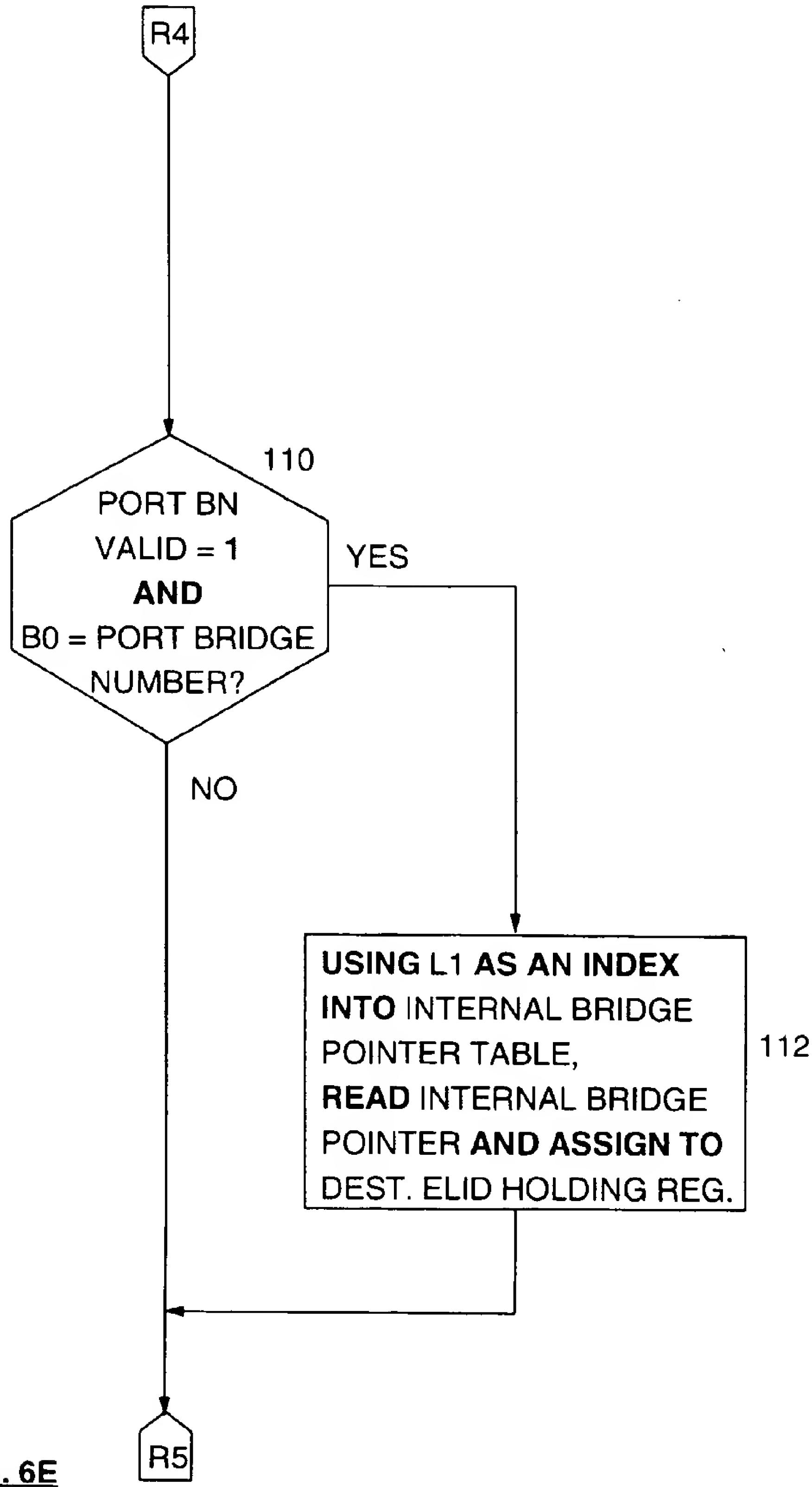

R4
110
PORT BN VALID = 1 AND B0 = PORT BRIDGE NUMBER?
YES
NO
USING L1 AS AN INDEX INTO INTERNAL BRIDGE POINTER TABLE, READ INTERNAL BRIDGE POINTER AND ASSIGN TO DEST. ELID HOLDING REG.
112
R5

FIG. 6E

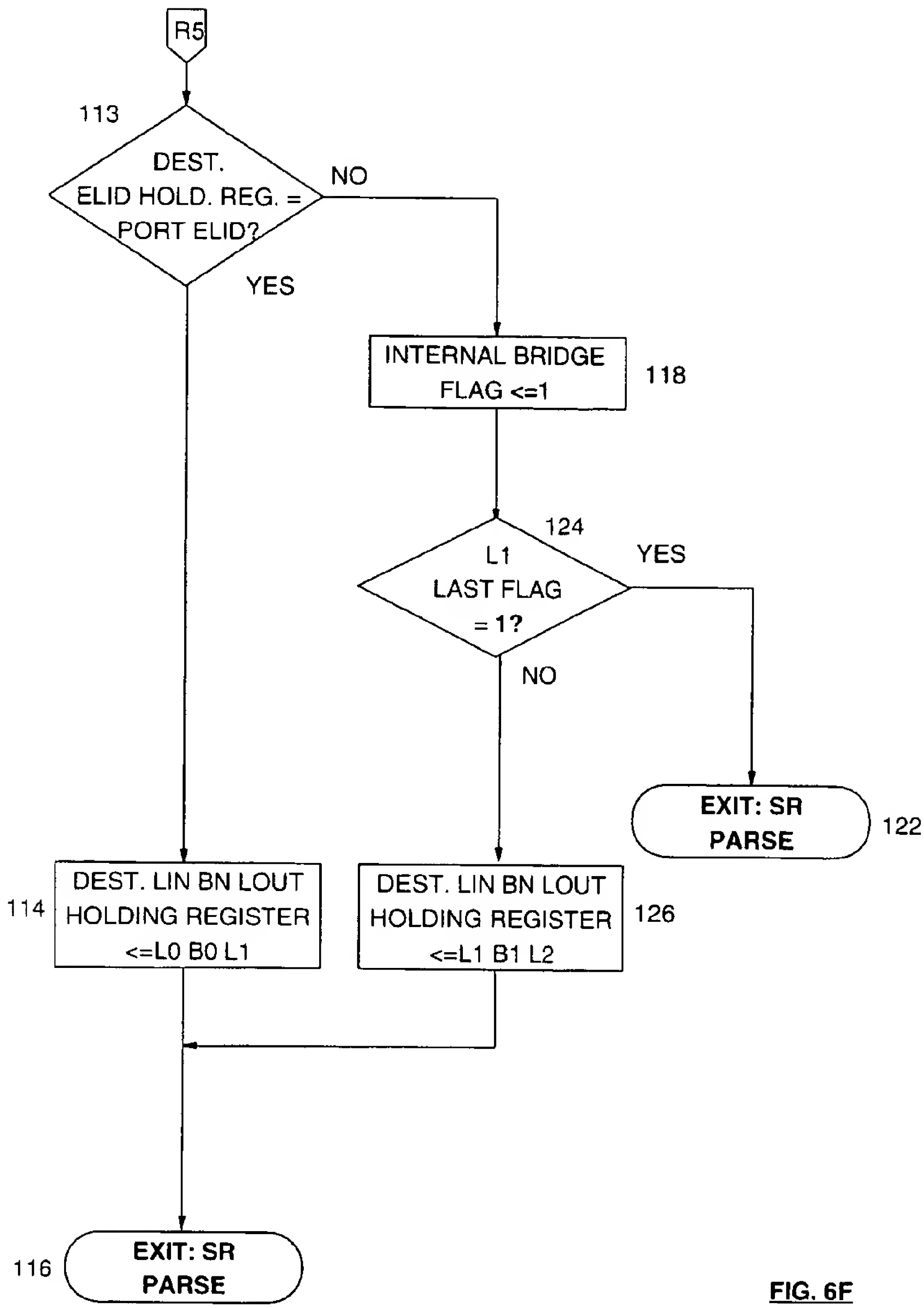

R5
113
DEST.
ELID HOLD. REG. =
PORT ELID?
NO
YES
INTERNAL BRIDGE
FLAG <=1
118
124
L1
LAST FLAG
= 1?
YES
NO
EXIT: SR
PARSE
122
DEST. LIN BN LOUT
HOLDING REGISTER
<=L0 B0 L1
114
DEST. LIN BN LOUT
HOLDING REGISTER
<=L1 B1 L2
126
116
EXIT: SR
PARSE

FIG. 6F

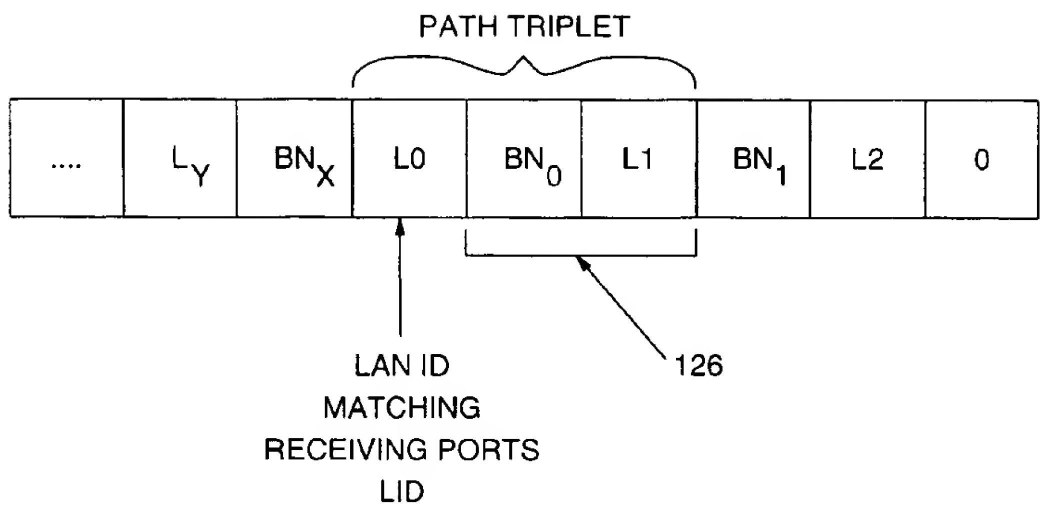

PATH TRIPLET
....
L_Y
BN_X
L0
BN_0
L1
BN_1
L2
0
LAN ID
MATCHING
RECEIVING PORTS
LID
126

FIG. 7A

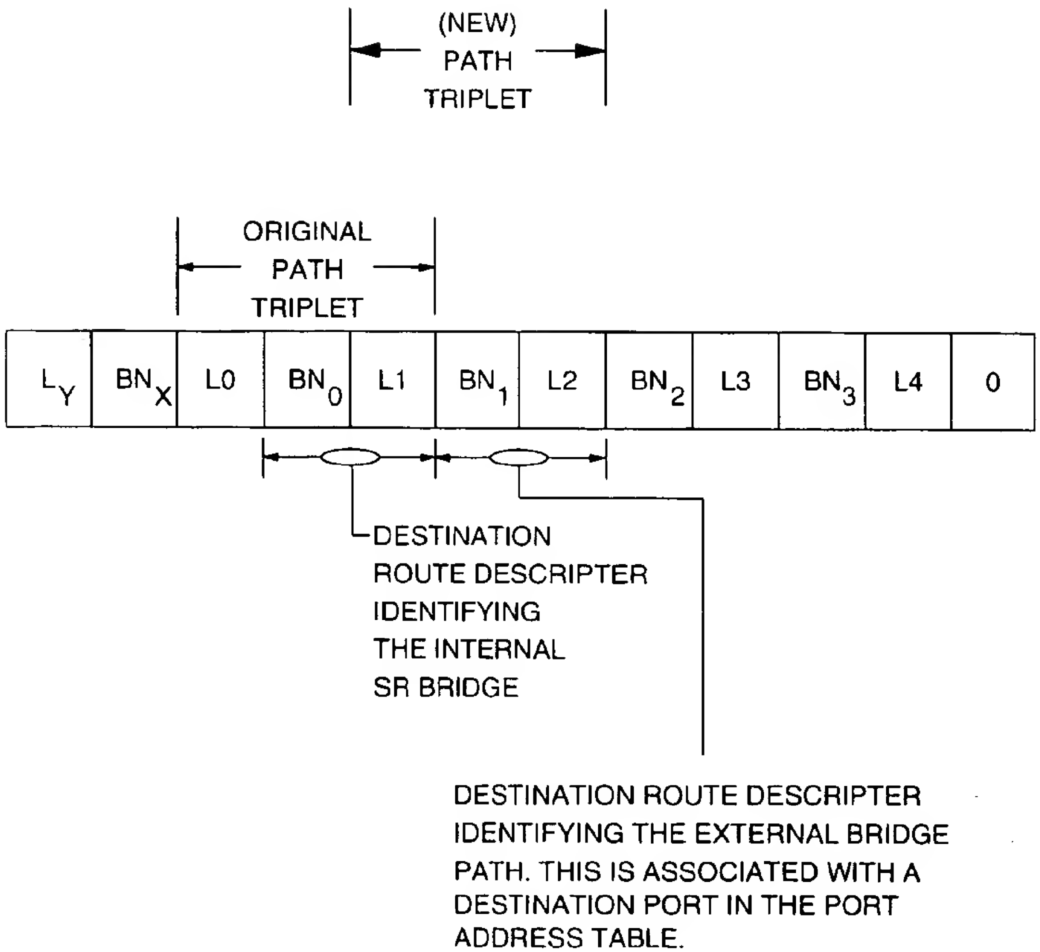

(NEW)
PATH
TRIPLET
ORIGINAL
PATH
TRIPLET
L_Y
BN_X
L0
BN_0
L1
BN_1
L2
BN_2
L3
BN_3
L4
0
DESTINATION
ROUTE DESCRIPTER
IDENTIFYING
THE INTERNAL
SR BRIDGE
DESTINATION ROUTE DESCRIPTER
IDENTIFYING THE EXTERNAL BRIDGE
PATH. THIS IS ASSOCIATED WITH A
DESTINATION PORT IN THE PORT
ADDRESS TABLE.

FIG. 7B

PROCESS DEFINITION FOR SOURCE ROUTE SWITCHING

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates to devices for interconnecting networks in general and, in particular, to the type of devices termed switches.

2. Prior Art

The use of devices for interconnecting communications networks are well known in the prior art. The devices are known by different names including gateways, bridges, hubs, routers, switches, etc. In spite of what they are called, these devices provide interconnection features which enable a device on one communications network, such as a LAN, to communicate with another device on another LAN. Examples of prior art interconnecting devices will now be described.

U.S. Pat. No. 5,088,090 discloses a bridge for interconnecting LANs. Based upon information contained in a frame header, the bridge uses Source Routing Technique or Transparent Bridging Technique to forward the frame from one LAN to another. The routing technique used in the bridge is dependent on the one used by the originating node. For example, if the originating node is a Source Routing Node, the bridge uses

Source Routing Technique to forward the frame. Likewise, if the originating node is a transparent bridged node, the bridge uses Transparent Bridging Technique to forward the frame.

U.S. Pat. No. 5,280,480 describes a bridge for routing frames from Source Routing nodes or Transparent Bridging nodes. The patent uses Bridge Protocol Data Unit (BPDU) Frame to set the bridge in a forwarding or blocking state and uses information in the header of Non-BPDU frames to forward the frames using the Source Routing technique or Transparent Bridging technique.

Even though the above bridge devices work well for their intended purposes, they are basically two port devices and offer limited interconnecting options. Arguably, several bridges can be configured to form complex networks of interconnected LANs. However, such networks are usually costly, difficult to configure and difficult to manage.

In addition, it is believed that as LANs become more congested (due to network expansion, attachment of higher speed devices, etc.), there is a need to provide faster and more efficient interconnecting devices.

U.S. Pat. No. 5,274,631 describes a switching system for interconnecting ethernet LANs. Each of the ports are connected through a packet processor to a switch fabric. A system processor is also connected to the switch fabric. When a packet processor receives a packet from the port to which it is connected and if the packet processor knows the destination port, the packet is routed through the switch fabric to the port. If the destination port is unknown to the packet processor, the packet is routed through the switch fabric to the system processor to identify the destination port. In this switching system, routing is done based on the destination addresses. As a consequence, large look-up tables correlating addresses with ports are required at each port. In addition, this switch can only be used to interconnect ethernet LANs. Therefore, there is a need for a switching system to interconnect Token Ring LANs. The present invention described below provides such a switching system.

Other IEEE documents including 8802-S and P802.5R describe devices in which the port determination is made at different functional units within the system. These devices use multiple look-up tables and multiple process, steps to select ports through which a frame is to be routed.

SUMMARY OF THE INVENTION

It is one object of the present invention to provide a more efficient switching system than was heretofore been possible.

It is another object of the present invention to provide a switch system for interconnecting Token Ring LANs.

It is another object of the present invention to provide a switching system which forwards frames based upon the information in the Routing Information Field (RIF).

It is another object of the present invention to provide a device that will facilitate the forwarding of frames via an internal switch fabric to a unique destination port based upon both the RIF and the MAC address when applicable.

It is still another object of the present invention to reduce the number of look-up tables and number of steps used in identifying the Port of Exit for a frame. These and other objects are achieved by using the Triplet (LID-BN-LID) to make Port of Exit decisions; therefore, facilitating the merging of the bridging and switching functions into a simple state machine and look-up tables.

The present invention provides a port module, at each port of the switch system, for filtering or forwarding frames. On receiving a frame from a LAN segment, the port module examines the Routing Information Indicator (RII) bit to determine its state. If the bit is set to "0", the frame has no Routing Information (RI) Field and the filtering and forwarding decision is based upon the Medium Access Control (MAC) Address in the frame.

If the frame has an RI field, the RII bit is set to a "1", the filtering and forwarding decisions may be based upon the information in the RI field or the MAC address. The Filtering Mechanism, a part of the port module, parses the RI Field to detect if an internal source route bridge path (e.g., internal to this switch) and/or if a known external source route bridge path (e.g., external to this switch) is indicated. A so-called Path Triplet is formed that can be used by the switch logic at the receiving port to identify the destination port to which the frame is to be forwarded. The Path Triplet is expressed as "LAN ID" (Identification)—Bridge Number—LAN ID. The notation L0-B0-L1 is used to represent the Path Triplet. The first LAN ID, L0, of the Path Triplet identifies the LAN Segment or Ring Number assigned to the switch port that receives the frame. Likewise, the second LAN ID, L1, of the Path Triplet is used to identify the destination LAN Segment (Ring Number), and thus the destination switch port, to reach the destination station.

The Path Triplet uniquely identifies a Source Route Bridge Path between the two LAN IDs, L0 and L1. If the switch logic of the receiving port determines that the Path Triplet indicates a source route bridge path that is external to the switch and local to the receiving port, the frame is discarded. If the switch logic of the receiving port determines that this source route bridge path is internal to the switch, then a second, overlapping Path Triplet, if present, is formed beginning with the second LAN ID (L1) of the original Path Triplet. The new Path Triplet is designated L1-B1-L2 that identifies a source route bridge path that is external to the switch. This unique sequence is used by the source switch port logic to uniquely identify the target port to reach the destination station.

In particular, the filtering mechanism, in each port module, scans the RI field to detect a LAN ID (LID) matching the LID of the ring to which the port is connected. The LID of the ring is stored in the Port LID/Register in the Associated Port Module. If a matching LID is found, it is referred to as "L0" and all other Triplets (LAN ID-Bridge Number-LAN ID) are referenced relative to L0. The numbers associated with a LAN ID-Bridge Number-LAN ID indicate the relative position of the LAN ID Bridge in the Route. By noting the position of L0 in the routing information field, the Route Descriptor is determined and is used to identify the port to which the frame is to be routed.

The switch port logic determines if the Path Triplet, L0-B0-L1, identifies the internal source route bridge path. If not, then the B0-L1 Destination Route Descriptor identifies a Source Route Bridge path that is external to the switch and uniquely identifies the next hop for the frame to traverse. If the indicated Destination Route Descriptor is local to the source switch port (e.g., the identified Source Route Bridge path, B0-L1, is on the same ring, L0, as the receiving switch port), then the frame can be discarded (i.e., filtered) by the switch port logic. If the Destination Route Descriptor hop is not local to the source port, then B0-L1 Destination Route Descriptor is used to identify the target port based on a matching entry of known external source route bridge paths within the switch port address table.

When the Path Triplet identifies the internal source route bridge path, the LAN ID, L1, will uniquely identify the destination port if there is only one port associated with that LAN ID. However, the switch architecture allows more than one port to share the same LAN ID. In this case, an external source route bridge path, if present, is identified in the Path Triplet, L1-B1-L2. The B1-L2 Destination Route Descriptor is unique for a given source route bridge path between ring L1 and ring L2 and can be used to identify the target port via the source port's look-up table of known external source route bridge paths. The look-up table within each port is maintained by the central switch processor. Two types of records are maintained; namely, Address Record and External Bridge Record. The look-up table is unique for each port and contains the following information:

- A 6-byte address for each station accessible on this port
- A 2-byte Bridge Number—LAN ID for each Source Route Bridge accessible on this port
- A 6-byte address for each remote station accessible via another port of this switch, along with the target Port of Exit (POE) tag
- A 2-byte Bridge Number—LAN ID for each remote Source Route Bridge accessible via another port of this switch, along with the target POE tag

MAC Addresses and Route Descriptor information are "learned" by the central processor and stored in both the master and port(s) address tables. These tables are periodically checked to remove entries that are deemed to be inactive (aging).

In one feature of the invention, the order of the Path Triplet is reversed. For example, after parsing, the Path Triplet reads L0-B1-L1, the reordered Path Triplet is L1-B1-L0. By reordering the Path Triplet and using it to perform the look-up in the filter table, the filtering is done in one direction only (i.e., away from the switch). As a consequence, port identification is done much faster and easier.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows a block diagram of a communications networks and the interconnecting device.

FIG. 2 shows a detailed block diagram of the interconnecting device according to the teachings of the present invention.

FIG. 3 shows a block diagram of Source Routing Token Ring Port Chip (STP CHIP).

FIG. 4 shows a graphical representation of the Frame Format.

FIG. 5 shows block diagram of the Filter State Machine (FSM).

FIGS. 6A through 6F show flowcharts for the routing process according to the teachings of the present invention.

FIG. 7, consisting of FIGS. 7A and 7B, illustrates a graphical representation for parsing the Route Descriptor Field to determine Port of Exit.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

FIG. 1 shows a communications network comprising a plurality of LAN Segments 1 through N interconnected by an Interconnecting Device 10 , which is referred to as a Token Ring LAN Switch. As used in this application, a Switch or Switch System refers to an interconnecting device in which a switching fabric is used to couple the ports.

Both Transparent and Source Route Bridge Paths are used to couple ports. An Internal Bridge Device 21 , when present, provides a Source Route Bridge Path between two or more ports. Both the Internal Bridge Path and the External Bridge Paths are represented by the sequence LAN ID—Bridge Number—LAN ID. This sequence is referred to as the "Path Triplet" in this invention. It should be noted that this illustration does not encompass all of the configuration options that are possible or that are supported by the switch device. It should be noted that rings on different ports may be assigned the same ring or LAN segment number. This is typical of a switch device and is a differentiating feature from current bridge devices. Limitations in bridges require that Source Route (SR) bridges have different ring numbers assigned to each port. Further, where the topology supports multiple bridges connected between rings, the bridge numbers must be unique.

The Interconnecting Device 10 illustrated supports both LAN segments and single data terminal equipments, only one is shown as DTE 12, connected to individual ports. A port of the switch labelled 'Fat Pipe (FP)' is connected to other high speed networks.

Still referring to FIG. 1, the Interconnecting Device 10 includes a Housing 10', a plurality of ports (Port 1 through Port N), a plurality of port modules (1 through N), a System Controller 12, and a Switch Fabric 14. The ports are connected to the housing and include electrical connectors (not shown) which coact with external connector to connect a LAN Segment, a DTE or a high speed network to the Switch. Each port is connected by a Port Module to the Switch Fabric 14. The Port Module (details to be given subsequently) is itself a contained unit and provides all of the electrical components for routing a Token Ring frame received on one port to a station located on another port of Device 10 via the Switch Fabric 14. The Fat Pipe Module 16 provides the interconnection between the Fat Pipe Port 18 and the Switch Fabric 14. The System Controller 12 provides the necessary management and control functions for the overall Switching System. A System Control Bus 20 couples the System Controller 12, the Switch Fabric 14, and each of the Port Modules and Fat Pipe module. The Switch Fabric 14 provides the switching function between the

respective modules. Its structure could be a simple high speed bus to a more complex multi-point switching module.

FIG. 2 shows a block diagram of the Switch System according to the teachings of the present invention. Components in FIG. 2 that correspond to components in FIG. 1 are identified with common numerals with a prime (') indicating that it is in a different figure. The System Controller 12' includes CPU 22, Buffer 24, Buffer 26, and CPU Memory 28. The Buffers 24 and 26 are connected to the CPU Bus 20' and the CPU Memory 28 is connected to Buffer 24. As stated before, the System Controller 12' is the Switch Level Processor. Its major functions are filter management, statistic gathering/reporting and initialization of the switch hardware and software. The CPA INTF 30 is the memory manager which manages CPU Memory 28 and the Network Memory 32. The Network Memory 32 stores frames to be sent to and received from the Switch Fabric 14'.

Still referring to FIG. 2, the port modules 1' through N' are identical. Therefore, only one will be described, it being understood that this description is intended to cover all of the port modules. The Port Module (for example, 1') includes a Network Interface (such as 1") connected by a Bus 34 to Source Routing Token Ring Port (STP) Chip such as 36. A pair of the Video Random Access Memory (VRAM) are connected to the STP Chip. The STP Chip is connected to the Switch Fabric 14'. The network interface includes the appropriate connection for connecting to a Token Ring LAN. In addition, the Network Interface provides the MAC level protocol for forwarding and receiving frames from a Token Ring LAN. In the Token Ring environment, the protocol is the IEEE 802.5 Token Ring protocol. The functions provided by the network interface are well known; therefore, further description will not be given. The STP Chip provides the filtering function that enables a Token Ring frame received at one port to be forwarded to another port of the Switching System. The VRAM provides storage function necessary to perform the filtering. The FP module 16' is connected to an SRAM. The function of the FP module 16' is to provide interconnection between a high speed LAN (such as 100 Mpbs FDDI or 155 Mbps ATM) and devices connected to other ports of the Switch System.

Turning to FIG. 4 for the moment, a graphical representation of the frame format which transports information within the Switch System is disclosed. The frame is structured in accordance with the teachings of the IEEE 802.5 standard for Token Ring. The frame includes a Start Delimiter (SD) field, an Access Control (AC) field, a Frame Control (FC) field, a Destination Address (DA) field, Source Address (SA) field, Routing Information RI Field (RIF), Information (INFO) field, and an End Delimiter (ED) field. The functions and purposes of the respective fields are well known in the communication art, therefore only those fields that are of immediate interest to the present invention will be described in detail. The first bit of the Source Address Field is termed Routing Information Indicator (RII) bit. The state of the bit indicates whether the frame has an RIF or not. If the bit is set to a logical "1", there is an RIF in the frame. Likewise, if the bit is set for logical "0", there is no RIF in the frame. The RII bit is set by the Source Station.

Still referring to FIG. 4, the RIF has a Routing Control (RC) field and a Route Descriptor (RD) field. The purpose of the RIF is to route a frame throughout the network. To this end, the RC field has a Routing Type (RT) subfield which is used to indicate the frame type. For example, if RT is set to "10X" B, it is an All Routes Explorer (ARE) frame. Likewise, if RT is set to "11X" B, it is a Spanning Tree Explorer (STE) frame. The decision which is made in routing each of the frames through the switch depends on the frame type. The LTH subfield is the length field and indicates the length of an RIF. The D subfield represents the direction, and depending on its setting, tells the direction in which the RIF is examined. The LF subfield is provided with information and represents the largest frame supported by the end-to-end path. The r represents a Reserve bit. Finally, the RD1, RD2 . . . RDN represent the route descriptors that are inserted in the frame by the source route bridges that comprise the path. The protocol that determines the RIF used by stations is known. As pointed out above, the Route Descriptors are structured in the sequence of LAN ID-Bridge Number-LAN ID. The sequence LAN ID-Bridge Number-LAN ID is termed a "Path Triplet". It should be noted that LAN ID and Ring Number are used synonymously. As will be described in more detail below, each Source Routing Token Ring Port (STP) Chip on receiving frames, determines if the frame has a Routing Information field by examining the state of the RII bit. If the RII bit is set to "0", the Chip concludes there is no RI field and the frame is routed based upon the MAC Address information in it. If the RII bit is set for "1", the frame has a routing information field structured in the TRIPLET sequence, as set forth above, and the STP Chip parses the RD subfield to extract the Path Triplet which are used to access filter tables (to be discussed subsequently) in the VRAM to determine the port of exit (POE) to which the frame is to be routed. As stated above, if the frame has no RI field, then the look-up function is done based upon the MAC address. This is a straight forward table look-up which will not be discussed further.

FIG. 3 shows a block diagram of the STP Chip. As pointed out above, the STP Chips in the switch are identical and description of one is intended to cover description of all. The STP Chip is positioned in each of the port modules and performs the filtering and forwarding functions that moves a frame from one port to another or discards the frame. The STP Chip is connected between the System CPU Bus 12", the Switch Fabric 14' and the Bus 34' connecting the STP Chip to the network card. The STP Chip includes a Packet Transfer Interface 36 including TX (Transmit) FIFOs (VRAM #1) and RX (Receive) FIFO VRAM #0. The respective VRAMs are coupled through a Switch Fabric Interface (INTF) 38 to the Switch Fabric 14". The TX FIFOs are connected by independent bus to the Bus Interface 39 which is connected to Bus 34'. The receive FIFO receives frames coming in from the port to which it is connected. A Received frame, after processing by the Filter and Forward Machine Means (details to be given subsequently) in the Packet Processing Means 41 of the STP Chip, is passed to the Switch Fabric 14" via the Switch Fabric Interface 38. Likewise, frames from the switch fabric are passed through the Switch Fabric Interface 38 to VRAM 1 and then to the Bus Interface 39 to the associated port via Bus 34. Still referring to FIG. 3, the Filter and Forward Machine Means includes a Frame Filter Means, a Frame Routing Means and Local Access Port Record. A Statistic Record retention device is also provided in the STP Chip. The Frame Routing Means and the Frame Filter Means form an imbedded Function State Machine Means (FSM) which is in each of the port modules and performs the filter/forward function described by this invention. The local access port record includes a Port ID that identifies the port, Ring Number that identifies the ring connected to the port, and other statistical information for the port. The Function State Machine Means are key elements in the port for parsing the frame to

determine if a frame should be discarded or forwarded, and if forwarded, the Port of Exit (POE) that a received frame is to be sent. Statistical information are extracted and stored in the Statistical Record which is maintained in VRAM.

If the frame is to be discarded, the FFSM Means will move from state **206** to state **220** (Discard). Once the frame is discarded, the FFSM Means will move to the Idle state (**200**) and wait for the next frame.

TABLE 1

RII = 1	RC Invalid	RI Invalid	RI Length = 2	L0 Found	L0 Last	B0 = Bridge Number	Dest ELID = Port ELID	L1 Last	L0 First	Action
0	—	—	—	—	—	—	—	—	—	Use DA & SA
1	1	—	—	—	—	—	—	—	—	Discard Frame
1	0	1	—	—	—	—	—	—	—	Discard Frame
1	0	0	1	—	—	—	—	—	—	Use DA & SA
1	0	0	0	0	—	—	—	—	—	Discard Frame
1	0	0	0	1	1	—	—	—	—	Use DA & SEB
1	0	0	0	1	0	0	—	—	0	Use DA & SEB
1	0	0	0	1	0	0	—	—	1	Use DA & SA
1	0	0	0	1	0	1	1	—	0	Use DA & SEB
1	0	0	0	1	0	1	1	—	1	Use DA & SA
1	0	0	0	1	0	1	0	0	0	Use DEB & SEB
1	0	0	0	1	0	1	0	0	1	Use DEB & SA
1	0	0	0	1	0	1	0	1	0	Use DA & SEB
1	0	0	0	1	0	1	0	1	1	Use DA & SA

KEY:
DA = Destination Address
SA = Source Address
DEB = Destination External Bridge (using triplet)
SEB = Source External Bridge (using triplet)

The STP Function State Machine means performs four basic functions: it filters (discards) those frames that do not need to traverse the switch to reach the destination path or station; it determines the Port of Exit (POE) for a frame received from the port to which it is connected; it places a Switch Control Header in each frame received so that the frame can be routed to the specific POE to which a destination station is connected; and it updates the statistics associated with the frame.

FIG. **5** shows the logic for the Filter/Forward State Machine (FFSM) means which is used to make the decision to either forward the frame through the switch or discard the frame. State **200** is the state used to wait for a frame to arrive at this port. Once a frame arrives, the Filter/Forward State Machine moves to the Load Frame Info state (**202**). In this state, the FFSM Means loads the necessary information from the frame in order to make the correct filter or forward decision. After the necessary amount of information has been loaded, the FFSM Means moves to the Set Flags (**204**) state in order to set all the flags needed to make the correct decision. The FFSM Means then transitions to state **206** and examines the flags set during state **204** and makes the appropriate filter or forward decision. Normally, if the frame is invalid, or the destination is local to the receiving port, the frame will be discarded. When the destination is through the switch, the FFSM Means will determine to which port to send the frame.

Still referring to FIG. **5**, if the frame is to be forwarded through the switch, the FFSM Means will move to the **208** state and build the appropriate header in order to forward the frame. Once the header has been constructed, the frame will be emptied from the FFSM (state **210**) and sent to the appropriate switch port in order to get to the destination. Once the frame has left the port, the FFSM Means will update the necessary statistics (state **212**) for the frame and then return to Idle (state **200**).

Table 1 shows how the FFSM Means determines which portion of the frame to use for the switch header (POE) lookup. If the frame is not to be discarded, the FFSM Means uses either the Destination Address (DA) of the frame or the Destination External Bridge (DEB) as determined from the algorithm's (described hereinafter) setting of appropriate flags and the Table 1. Once the appropriate destination record is determined, the FFSM Means uses the table to determine which source record to use.

If the table states that the SA is to be used, then the Source Address record is used as part of the lookup function. If the table states that the SEB should be used, then the FFSM Means uses the Source External Bridge (preceding triplet with L0 being at the end) as the source record. Using these two records, the FFSM Means can determine exactly which switch port should receive the frame.

The STP Mechanism includes Function State Machines and logic to control the Function State Machines. The flowchart which describes the detail function of the Filtering Machine will be described next.

The process used in the Filtering Machine to discard or forward a frame will now be described. First, an overall description of the process will be given, followed by a detailed description with flowcharts identifying detailed steps of the process. The process initially characterizes the frame that has been received from a LAN segment by examining the Routing Information Field (RIF) if it is present in the frame as indicated by Routing Information Indicator (RII) bit of the Source Address Field. If present, the RIF must be parsed to determine if the receiving port should forward or discard the frame. This parsing process also produces a result that is then used to establish the target port for the frame if it is to be forwarded.

The major steps of the Process are as follow:

1. Is the Frame Source routed? Determine by testing the RII bit (high-order bit in Source Address field). If RII=1 then Go To Step 2. If RII=0,then Exit.

2. Test for valid Routing Information Field (RIF). This is determined by testing the RC length and RI broadcast

indicators. (The details of the test are set forth below.) Set Frame RC Invalid Flag=1 if invalid. Continue.

3. Test for RIF length of 2 bytes. Set RIF Length Two Flag=1 if true. Continue.

4. Test for All Routes Explorer (ARE) frame. Set ARE Frame Flag=1 if true. Continue. Test for Spanning Tree Explorer (STE) frame. Set STE Frame Flag=1 if true. Continue.

Note: Either ARE or STE can be true. Both can be false.

5. If RIF Length Two Flag=0, then

5a. Scan Route Descriptor (RD) field for LAN ID (LID or LIN) match.

5b. Is LID the first field in the Route Descriptor?

5c. Is LID the last field in the Route Descriptor?

6. If LID is not last, then locate the Path Triplet to be used:

6.1 Locate the LID in the Route Descriptor field

6.2 Identify triplet as L0, B-0, L-1 where L0=LID (see Triplet mapping described herein)

6.3 Does B-0, L-1 identify an internal bridge hop (within this switch)?

a. if Yes, is L-1 the Last ring? If not, locate the next sequential path triplet which is found beginning with L1 and is identified as L1-B1-L2.

b. if no, then Continue.

7. Destination Search type is now determined.

IF

Route Descriptor contains LID, (5*a*)=Yes

LID is first, (5*b*)=No

There is no internal bridge hop, (6.3)=No

OR

IF

Route Descriptor contains LID, (5*a*)=Yes

LID is first, (5*b*)=Yes

There is an internal bridge hop, (6.3)=Yes

Is L-1 last? (6-3a.1)=No

THEN

A Destination Route Description search is performed using the

Destination Route Descriptor formed from the Path Triplet identified in (6).

ELSE

A Destination Address Search is performed based on the Destination

Address (DA) found in the frame.

FIGS. 6A through 6F show detailed flowcharts of the process. With respect to FIG. 6A, the process (termed Source Route-SR Parse) begins in block 40 and descends into block 42 where the first byte of the source address is read. The process then descends into block 44 where the Routing Information Indication (RII) bit is tested. The RII bit is the first bit in the first byte of the frame source address. If the frame RII bit is not=1, the process exits the Source Routing (SR) parse process block 46. If the frame RII bit is equal to 1, the process continues to block 48 where it sets the RII flag to a 1. The process reads the frame routing control field (52) and sets flags based on an examination of the RC. In particular, and with respect to FIG. 4:

IF(Frame RC length is 0, 4, or odd) OR (Frame RI Broadcast Indicator Bits='1xx'b

AND Frame RI direction Bit=1)

THEN Frame RC Invalid Flag is set to <=1

IF(Frame RC Length=2)

THEN RI Field Length Two Flag is set to <=1

IF(Frame Broadcast Indicator Bits='10X'b)

Then ARE Frame Flag is set to <=1

IF(Frame Broadcast Indicator Bits='11X'b)

THEN STE Frame Flag is set to <=1

After the flags are set based on the above conditions, the process exits FIG. 6A at R1. Referring to FIG. 6B, the process continues from R1 to block 56. In block 56, the process checks to see if the Frame Routing Control Invalid flag is set to 1. If it is, this means the RC field is invalid and the program exits the process at block 58. The frame that was being parsed is then discarded. If the frame RC is not invalid, the process examines all the Frame Route Segments in the RIF. As stated previously, the Route Descriptors form a sequence of LID-Bridge Number-LID.

Still referring to FIG. 6B, and in particular block 64, it checks to see if the RI Field Length equals 2 bites. If it is, the process exits at block 70.

FIG. 6C shows that the process continues the parsing technique from R2 into block 72 where it checks to see if the frame RI field is valid. If valid, the process continues. If the RI field is invalid, the process exits at block 74. The received frame RIF is invalid if the (Frame Byte Count—18)<(Frame RI Length) or if duplicate LAN IDs are present. Usually, the frame is discarded if it is found that the RI field is invalid.

Still referring to FIG. 6C, from block 72 if the RI Field is valid, the process then descends into block 80 where it searches for L0 by scanning the Route Descriptors to match with Port LAN ID. It should be noted that L0 is the identification of the LAN which is connected to the port which receives the frame. It should be noted that several records with information about each port of the switch are stored in Port Registers. The ID of the ring connected to a port is one of the many records stored in the port. From block 80, the process descends into block 82. If L0, which is the ID for the LAN connected to the port is not found, the process exits block 84. In block 82, if L0 is found in the RI field, the process descends into block 86. The L0 Found Flag is set to a logical 1 and exits FIG. 6C, at R3.

FIG. 6D shows a continuation of the Parsing Process beginning with block 86 where the process checks to see if L0 is the first LAN ID. If L0 is the first LAN ID, the process descends into block 88. In block 88, the process sets the SL Rem Flag to a 1 and the source LAN In Bridge Number LAN Holding Out Register is set to L0 B-1 L-1. In essence, in block 88 the Path Triplet is found and identified. The term first and last as used in FIG. 6D takes into consideration the setting of the Direction Bit (FIG. 4) and refers to the first or last LAN ID in the route. For example, if the Direction Bit is a "0", then the "first LAN ID" appears in the frame immediately after the Routing Control Field (See FIG. 4). If the Direction Bit is a "1", then the first LAN ID is at the end of the RI field.

Still referring to FIG. 6D, and in particular block 86, if L0 is not the first LAN ID, the process descends into block 90. In block 90, the process checks to see if L0 is the last LAN ID. If L0 is the last LAN ID, the process descends into block 92. In block 92, the L0 last flag is set to 1 and the process exits at block 94. If L0 is not the last LAN ID (block 90), the process descends into block 100. In block 100, the process checks to see if L1 is the Last LAN ID. If it is, the process enters block 102 where it sets the L1 Last Flag to a 1 and exits to FIG. 6E. If L1 is not the Last LAN ID, the process exits to FIG. 6E.

The process enters FIG. 6E at block 110. In block 110, the process checks to see if there is an internal bridge hop in the switch. The criteria for determining if an internal bridge is

in the switch is that the Port Bridge Number (BN) is valid; i.e., set for 1, and the B_0 is equal to the Port Bridge Number. If these criterion are met, the process descends along the Yes path into block **112**. In block **112**, the process checks to see if there is part of the internal bridge on LAN ID L-1. If there is not, then the returned Encoded LAN ID (ELID) will match the ports ELID. More particular, in block **112** the process uses the L1 as an index into the Internal Bridge Pointer Table. The information read from the table is stored in the destination Encoded LAN ID (ELID) Holding Register. The process then exits FIG. **6E** into FIG. **6F**.

In FIG. **6F**, the process checks to see the information in the destination ELID Holding Register equals the information in the Port ELID. If it does, the process descends along the Yes path into block **114** where it sets the Destination Holding Register with the Path Triplet L0 B0 L1 and exits the process in block **116**. In essence, block **114** indicates no Internal Bridge Hop. If in block **113**, the information in the two registers are different, the process descends into block **118**, where it sets the Internal Bridge Flag to a 1 and descends into block **129**, where it checks to see if the duplicate L1 flag is set for 1. If it is, the process exits the routine at block **122** and the frame is discarded. If the duplicate L1 flag is not set to 1, the process descends into block **124** where it checks to see if the L1 Last Flag is set for 1. If it is, the process exits through block **122** and a Destination Address search occurs. If in block **124** the L1 Last Flag is not set for 1, the process descends into block **126**. In block **126**, the process sets the Destination LIN-Bridge Number-LOUT Holding Register to L1 B1 L2 and exits the process in block **116**.

The information in block **114** and **126** are used to access the look-up table described above to identify the exit port to which the information is to be routed.

A description of the operation of the invention will now be given. Frames are received from ports in the switch and are tested for a RIF. If the information in the RIF is valid, it is loaded into a Parsing Register, located in the VRAM (FIG. **3**).

The Register is always loaded in the same order. The transfer of data from the RIF to the Register is controlled by the setting of the D bit in the RC field (FIG. **4**). For example, if D=0 and the information in the RD field is arranged in the pattern L0 B0 L1 B1 L2 B2 L3, the ordering in the RIF Register is L0 B0 L1 B1 L2 L3. If D=1, the RIF Register order is L3 B2 L2 B1 L1 B0 L0. Consequently, the processing of information in the RIF Register is made simpler.

Once the information is loaded in the register, it is parsed to determined whether or not the frame should be discarded or forwarded. Turning to FIG. **7A**, a graphical representation of parsing is shown. The Path Triplet includes L0-BN0-L1 with L0 being the LAN ID connected to the switch port and matching the LAN ID in the receiving frame. The section of the Path Triplet labeled **126** is termed a Destination Route Descriptor and identifies the next Source Route Bridge Hop that the frame will traverse.

With reference to FIG. **7B**, if the next Source Route Bridge Hop is within the switch, a New Path Triplet which overlaps the Original Path Triplet is determined with the respective Descriptors being those identified in FIG. **7B**. In the above description of FIGS. **7A** and **7 B**, D is assumed to be set to 0.

If the next Source Route Bridge Hop is not within the switch, the Destination Route Descriptor would be used to identify the Port of Exit (POE).

While the invention has been particularly shown and described with reference to the particular embodiment thereof, it will be understood by those skilled in the art that various changes in form and details may be made therein without departing from the spirit and scope of the invention.

Having thus described our invention, what we claim and desire to secure as letters patent is as follows:

We claim:

1. A Token Ring Switch for use to interconnect communications network including:

a switch fabric;

a plurality of ports;

a plurality of port modules interconnecting the plurality of ports to the switch fabric, with at least one of port module including a register for receiving a frame, and at least one look-up table including at least one address for each remote station accessible via another port of the switch along with the target Port of Exit (POE) tag and Bridge Number Lan ID for each remote source route bridge accessible via another port of the switch along with the target POE tag, means for identifying a source routed frame; state machine for analyzing the source routed frame and extracting a first expression identifying an external Source Route Bridge Path from which the frame was received and a second expression identifying an External Source Route Bridge Path for said frame; and

state machine for using the first expression or second expression to access the look-up table and identify the Port of Exit (POE) to which the frame is to be routed via the switch fabric.

2. The device of claim **1** wherein a format for the first expression and second expression includes a triplet notation LAN ID-Bridge Number-LAN ID.

3. The device of claim **2** further including means for reversing the order of elements in the triplet notation of L_0-B_1-L_1 to L_1-B_1-L_0, where L_0 represents a LAN ID, B_1 represents a Bridge Number and L_1 represents a LAN ID.

4. The Token Ring Switch of claim **1** further including an internal bridge coupled to the switch fabric of said Token Ring Switch.

5. The Token Ring Switch of claim **1** wherein the means includes a Filter Forward State Machine disposed at each port and programmed to perform the respective functions.

6. The Token Ring Switch of claim **5** wherein the Filter Forward State Machine is further programmed to extract a third expression identifying an Internal Source Route Bridge Path.

7. The Token Ring Switch of claim **1** wherein the switch fabric includes a high speed bus.

8. The Token Ring Switch of claim **1** wherein the switch fabric includes a multi-point switching module.

9. The Token Ring Switch of claim **1** further including state machine for generating and concatenating a switch control header to said frame so that the frame can be routed by the switch to the target Port of Exit to which the destination station is connected.

10. The Token Ring Switch of claim **1** further including means for using a Source Address or Destination Address in said frame to access another look-up table to identify the Port of Exit (POE) for said frame if said frame is a non-source routed frame.

11. A method for routing frames through a switch connected to a communications network comprising the steps of:

providing a switch fabric in said switch;

receiving at a port of said switch a frame;

examining the frame;

if the frame has an RI field, determining if L_0 (LAN ID) in the frame matches the LAN ID of the port;

if the L_0 in the frame matches the LAN ID of the port; using said L_0 to determine a first path triplet L_0-BN_0-L_1 with BN representing bridge number;

using BN_0-L_1 to determine a next bridge hop;

if the next Bridge Hop is within the switch, generating a second path triplet L_1-BN_1-L_2; and

using the second expression to access a look-up table from which a Port of Exit for said Frame is read.

12. The method of claim 11 wherein if the second bridge hop is not within the switch, using the first path triplet to identify the Port of Exit to which the frame is to be routed through the switch.

13. The method of claims 11 or 12 wherein only portions of the first path triplet or second path triplet is used to identify a Port of Exit.

14. A Token Ring Switch for use to interconnect communications network including:

a switch fabric;

a plurality of ports;

a plurality of port modules interconnecting the plurality of ports to the switch fabric, with each one of the plurality of port modules including a register for receiving a frame, port table that stores information including target Port of Exit through which a frame has to be routed to reach a destination station and at least one Function State Machine with the program logic to filter frames that do not need to traverse the switch to reach a Port of Exit to a destination, to parse a frame received from the port to which it is connected to extract information that is used to access the table and read the target POE, to place a Switch Control Header in selected frame received so that the frame can be routed to the specific POE to which a destination station is connected, and to update the statistics associated with the frame.

* * * * *

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United States Patent [19]

Portaro et al.

[11] Patent Number: 5,946,617

[45] Date of Patent: Aug. 31, 1999

[54] CELLULAR COMMUNICATION SYSTEM WITH REMOTE POWER SOURCE FOR PROVIDING POWER TO ACCESS POINTS

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[73] Assignee: **Telxon Corporation**, Akron, Ohio

[21] Appl. No.: **08/672,429**

[22] Filed: **Jun. 28, 1996**

[51] **Int. Cl.**[6] **H04B 7/26**

[52] **U.S. Cl.** **455/422**; 455/560; 455/572; 379/413

[58] **Field of Search** 455/402, 127, 455/343, 561, 560, 572, 422; 379/307, 322, 324, 413

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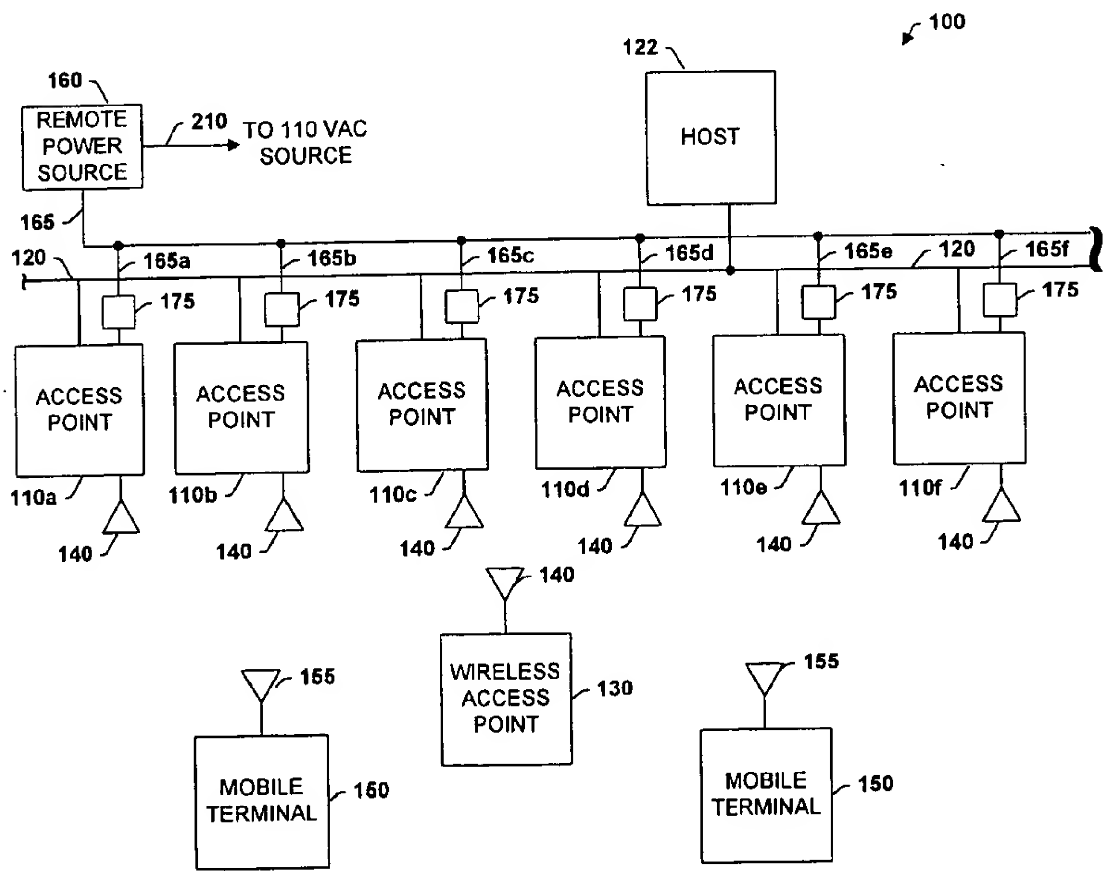
Primary Examiner—Thanh Cong Le
Attorney, Agent, or Firm—Renner, Otto, Boisselle & Sklar, P.L.L.

[57] **ABSTRACT**

A cellular communication system which eliminates high costs and difficulties associated with providing electrical power to the access points. The cellular communication system includes a remote power source which obviates the need to install an AC power outlet in close proximity to each access point. The remote power source transforms AC power to DC power at a central remote location, and provides as its output one or more low voltage DC power lines. By performing the AC/DC power transformation at a central location, only the low voltage DC power lines need to be fed to each access point. The remote power source also includes a backup power supply feature and an alarm to draw attention to system malfunctions.

19 Claims, 3 Drawing Sheets



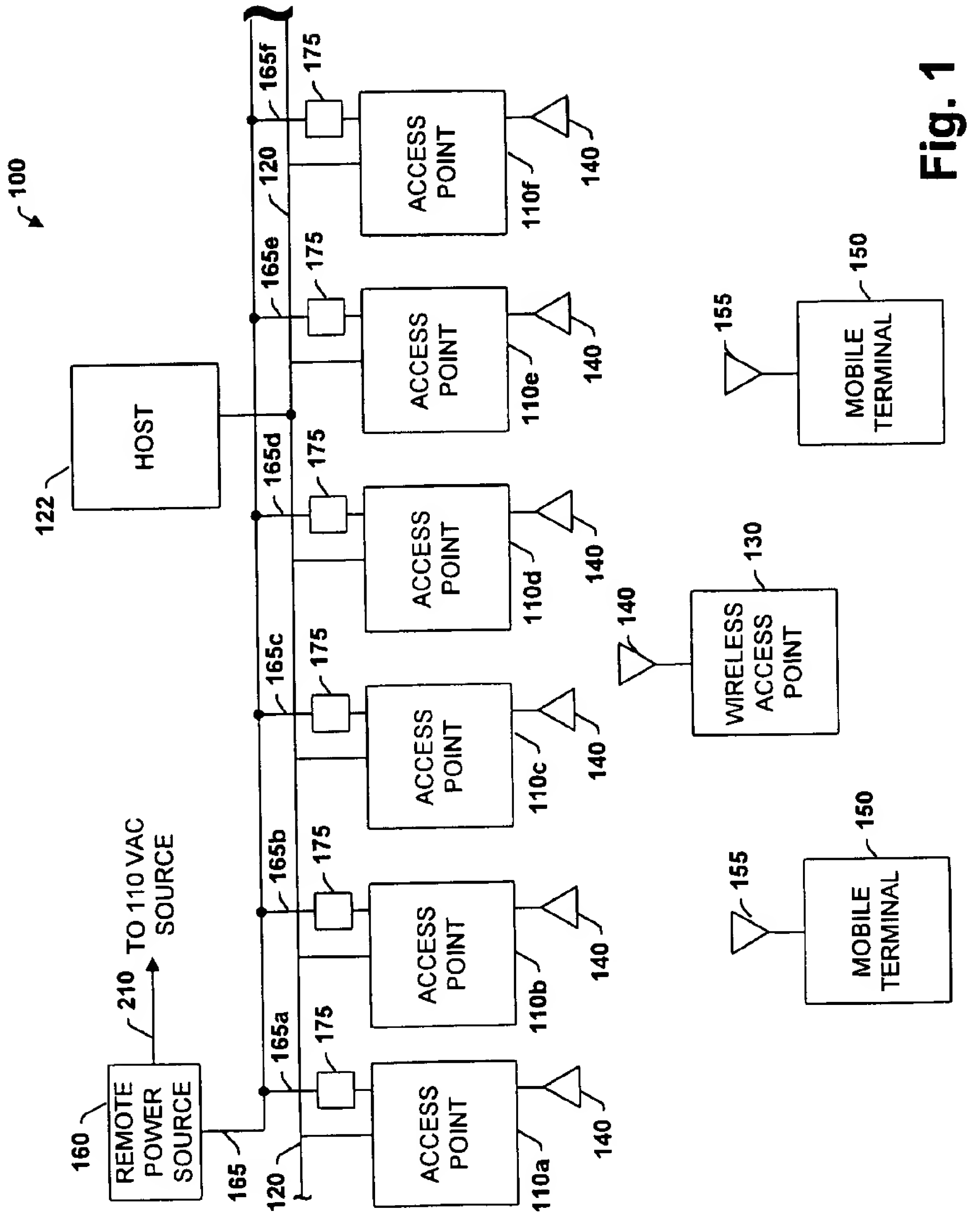
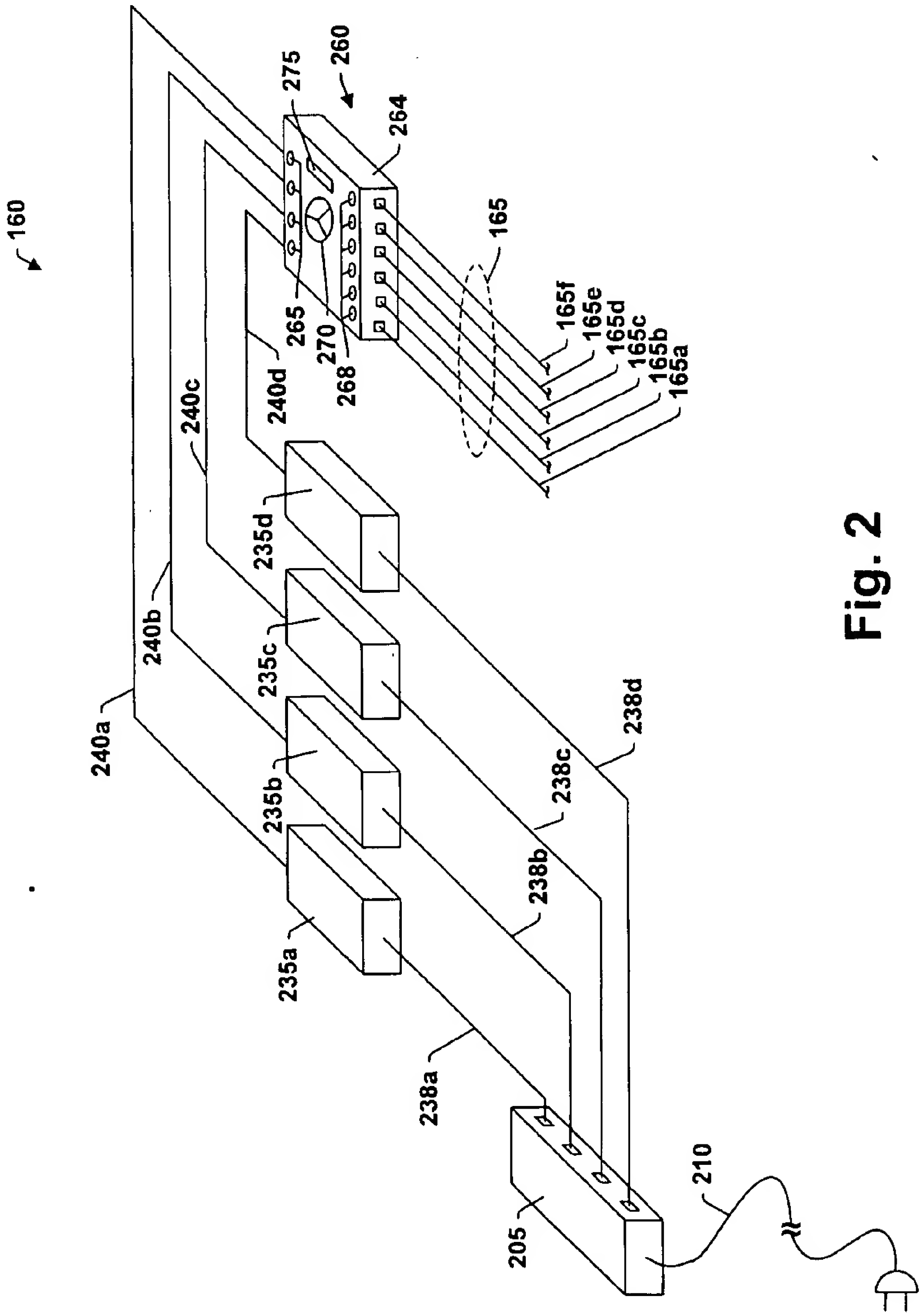

100
HOST
122
REMOTE POWER SOURCE
160
165
210
TO 110 VAC SOURCE
120
165a
165b
165c
165d
165e
165f
175
ACCESS POINT
110a
110b
110c
110d
110e
110f
140
WIRELESS ACCESS POINT
130
MOBILE TERMINAL
150
155

Fig. 1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260
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264
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165f
165e
165d
165c
165b
165a
265
270
268
240d
240c
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238a
205
210

Fig. 2

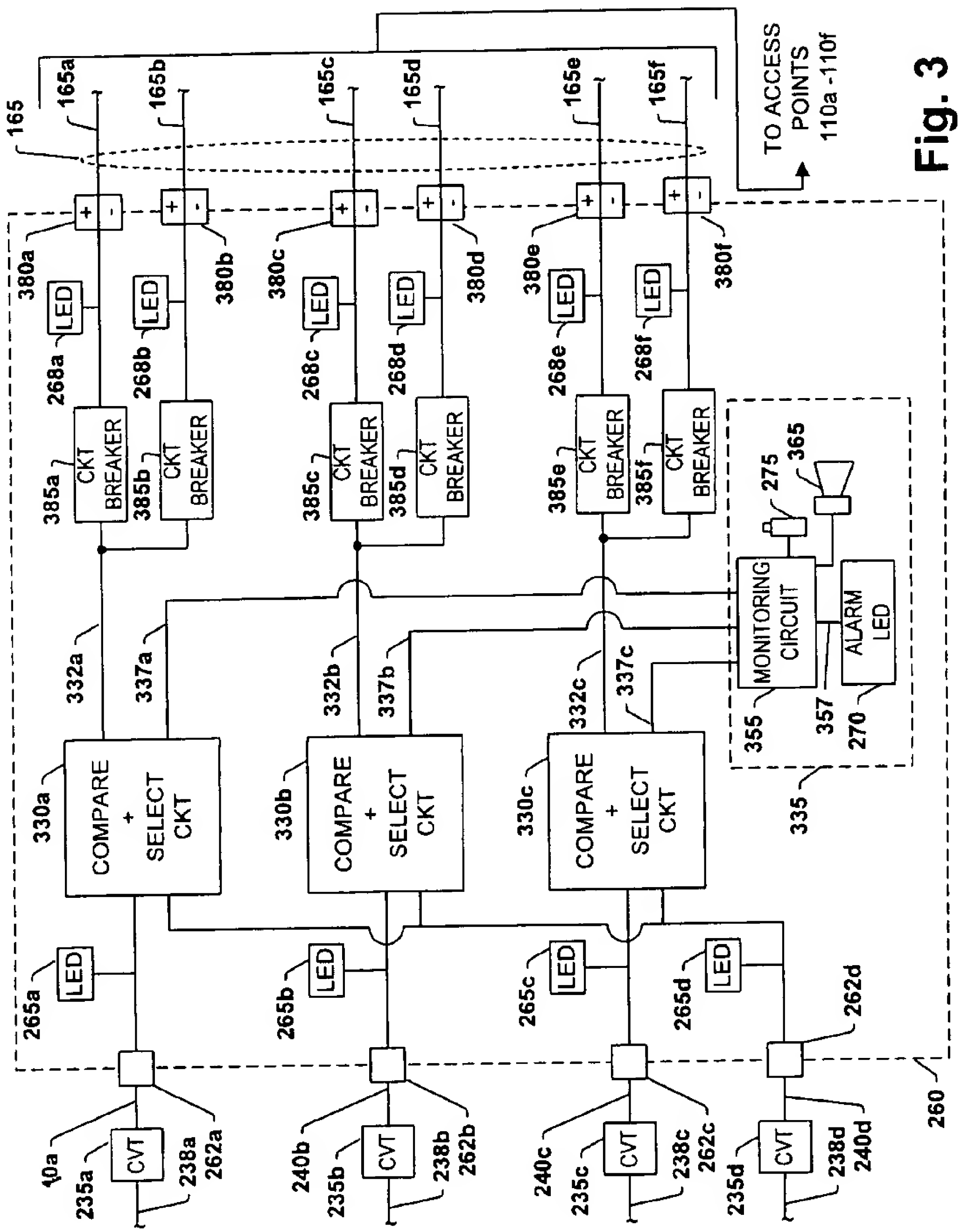
TO ACCESS POINTS 110a-110f
COMPARE + SELECT CKT
CKT BREAKER
LED
MONITORING CIRCUIT
ALARM LED
CVT

Fig. 3

CELLULAR COMMUNICATION SYSTEM WITH REMOTE POWER SOURCE FOR PROVIDING POWER TO ACCESS POINTS

TECHNICAL FIELD

The present invention relates generally to cellular communication systems, and more particularly to a cellular communication system including a remote power source for providing power to access points within the system.

BACKGROUND OF THE INVENTION

In recent years, the use of cellular communication systems having mobile devices which communicate with a hardwired network, such as a local area network (LAN) or a wide area network (WAN), has become widespread. Retail stores and warehouses, for example, may use cellular communication systems with mobile data terminals to track inventory and replenish stock. The transportation industry may use such systems at large outdoor storage facilities to keep an accurate account of incoming and outgoing shipments. In manufacturing facilities, such systems are useful for tracking parts, completed products and defects. Such systems are also utilized for cellular telephone communications to allow users with wireless telephones to roam across large geographic regions while retaining telephonic access. Paging networks also may utilize cellular communication systems which enable a user carrying a pocket sized pager to be paged anywhere within a geographic region.

A typical cellular communication system includes a number of fixed access points (also known as base stations) interconnected by a cable medium often referred to as a system backbone. Also included in many cellular communication systems are intermediate access points which are not directly connected to the system backbone but otherwise perform many of the same functions as the fixed access points. Intermediate access points, often referred to as wireless access points or base stations, increase the area within which access points connected to the system backbone can communicate with mobile devices. Unless otherwise indicated, the term "access point" will hereinafter refer to both access points hardwired to the system backbone and wireless access points.

Associated with each access point is a geographic cell. Such cell is a geographic area in which an access point has sufficient signal strength to transmit data to and receive data from a mobile device such as a data terminal or telephone with an acceptable error rate. Typically, access points will be positioned along the backbone such that the combined cell area coverage from each access point provides full coverage of a building or site.

Mobile devices such as telephones, pagers, personal digital assistants (PDAs), data terminals, etc. are designed to be carried throughout the system from cell to cell. Each mobile device is capable of communicating with the system backbone via wireless communications between the mobile device and an access point to which the mobile device is registered. As the mobile device roams from one cell to another, the mobile device will typically deregister with the access point of the previous cell and register with the access point associated with the new cell.

In order to provide sufficient cell area coverage, access points within the cellular communication system typically are distributed at separate physical locations throughout an entire building or set of buildings. For various reasons such as aesthetics, cell coverage, protection from the environment, etc., the access points typically are situated at locations hidden from view of the occupants and well removed from everyday traffic. Thus, it is not uncommon that access points are located above ceiling tiles or in other remote locations throughout the building or buildings.

At the same time, each access point must receive electrical power for operating the access point regardless of its particular physical location. In the past, it has been common practice to provide electrical power to each access point by installing a corresponding dedicated AC electrical power outlet (e.g., rated at 110 volts AC) in close physical proximity to each access point. Once installed, each access point is plugged into its dedicated AC outlet and receives operating power therefrom. Typically, the access point includes an AC-to-DC (AC/DC) converter which converts the power from the AC outlet to a suitable DC power level for operating the various electronics included within the access point.

Accordingly, the installation of a cellular communication system typically includes installation costs associated with adding an AC power line together with corresponding AC power outlets for each access point. Due to local electrical wiring codes, etc., each added outlet involves the cost of extra conduit and wiring needed to reach the location of the access point and the cost associated with hiring a licensed electrician to complete the work. Since the access points typically are located in difficult to reach locations (e.g., above ceiling tiles, etc.), installation of the AC wiring and conduit has been particularly time consuming for the electrician. As the number of access points required to serve a store or business is often large, the overall costs associated with supplying power to each access point has been high and adds significantly to the overall cost of installing a cellular communication system.

In view of the aforementioned shortcomings associated with the high installation costs for conventional cellular communication systems, there is a strong need in the art for a system which is less costly with respect to supplying power to access points within the system. In particular, there is a strong need in the art for a system which is both simple and inexpensive and does not require the high overhead associated with providing and installing dedicated AC power outlets.

SUMMARY OF THE INVENTION

The present invention provides for a cellular communication system which is not hampered by the aforementioned high costs and difficulties associated with providing electrical power to the access points. The cellular communication system of the present invention introduces a remote power source which obviates the need to install an AC power outlet in close proximity to each access point. The remote power source transforms AC power to DC power at a central remote location, and provides as its output one or more low voltage DC power lines. By performing the AC/DC power transformation at a central location, only the low voltage DC power lines need to be fed to each access point. Unlike AC power lines, low voltage DC power lines according to most local electrical codes are not required to be run through conduit and do not require installation by a licensed electrician. Furthermore, the DC power lines can simply be run along with other LAN wiring for the cellular communication network, thereby streamlining the entire power distribution and installation process. The remote power source of the present invention also includes a backup power supply feature and an alarm to draw attention to a system failure.

According to one particular aspect of the invention, a cellular communication system is provided. The system

includes a system backbone, a host computer coupled to the system backbone, a plurality of access points coupled to the system backbone and distributed at different physical locations at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points, and a remote power source for providing power to the plurality of access points. The remote power source is located remotely from at least one of the plurality of access points and includes an AC/DC converter for converting AC power to DC power and for providing the DC power at an output, and at least one DC power line extending between the output of the AC/DC converter and respective power inputs of the plurality of access points.

In accordance with another aspect of the invention, a method for providing power to access points within a cellular communication system is presented. The method includes the steps of converting AC power to DC power at a location which is remote from the location of at least one of the access points and providing the DC power at an output, and providing the DC power at the output to respective power inputs of the plurality of access points using at least one DC power line.

To the accomplishment of the foregoing and related ends, the invention, then, comprises the features hereinafter fully described and particularly pointed out in the claims. The following description and the annexed drawings set forth in detail certain illustrative embodiments of the invention. These embodiments are indicative, however, of but a few of the various ways in which the principles of the invention may be employed. Other objects, advantages and novel features of the invention will become apparent from the following detailed description of the invention when considered in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a block diagram of a cellular communication system including a remote power source in accordance with the present invention;

FIG. 2 is a block diagram of the remote power source in accordance with the present invention; and

FIG. 3 is a detailed block diagram of a power control section included in the remote power source in accordance with the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will now be described with reference to the drawings wherein like reference numerals are used to refer to like elements throughout. As mentioned above, the present invention relates to cellular communication systems which include mobile devices that can roam from cell to cell. Such mobile devices can be data terminals, telephones, pagers, etc. In the exemplary embodiment described hereinafter, the mobile device is a mobile data terminal (hereinafter "mobile terminal") used to communicate data such as inventory or the like. However, it is recognized that the invention contemplates other types of mobile devices and is not intended to be limited to systems utilizing mobile terminals.

Referring initially to FIG. 1, a cellular communication system 100 is shown in accordance with the exemplary embodiment of the present invention. The cellular communication system 100 includes a network having a system backbone 120. The system backbone 120 may be a hardwired data communication path made of twisted pair cable, shielded coaxial cable or fiber optic cable, for example, or may be wireless in nature. Connected to the system backbone 120 are several access points 110*a*–110*f* (referred to generally as access points 110) and a host computer 122. Each access point 110*a*–110*f* includes a radio transceiver (not shown) and serves as an entrance point through which wireless communications may occur with devices on the system backbone 120. The access points 110 are distributed, for example, at different physical locations throughout a building (e.g., above ceiling tiles or the like). The system backbone 120 in the case of a hardwired data communication path may be a cable which is routed through walls and/or above the ceiling throughout the building. Since the system backbone carries only low level signals similar to those associated with most LAN based systems, the system backbone 120 need not be enclosed in conduit and/or comply with rigid local electrical codes.

In order to expand the effective communication range of the access points 110*a*–110*f*, one or more wireless access points 130 are also included in the cellular communication system 100. As is conventional, each wireless access point 130 associates itself, typically by registration, with another access point, whether hardwired or wireless, such that a link is formed between itself and other devices situated on the system backbone 120. Each access point 110,130 is capable of wirelessly communicating with other devices in the system 100 via an antenna 140. For instance, the antenna 140 may be an omni-directional, yagi-type or other form of antenna as will be readily appreciated.

The cellular communication system 100 also includes one or more mobile terminals 150. Each mobile terminal 150 includes its own radio transceiver (not shown) and communicates with devices on the system backbone 120 via a selected access point 110 and/or with other mobile terminals 150. Similar to the access points 110, 130, the mobile terminals 150 communicate via an antenna 155.

Except as otherwise described herein, the construction and operation of the access points 110,130 and the mobile terminals 150 is conventional. As a result, additional detail has been omitted for sake of brevity.

In order to supply operating power to each access point 110*a*–110*f*, the cellular communication system 100 also includes a remote power source 160. As is discussed in more detail below, the remote power source 160 serves to transform AC power to DC power prior to distribution to each access point 110, thereby allowing simpler and more cost efficient installation. Further, the remote power source 160 also includes backup power contingencies in the event of a failure within the power source. Low voltage DC power is distributed from the remote power source 160 to each access point 110*a*–110*f* via dedicated DC power lines 165*a*–165*f* (referred to collectively as power line 165). The dedicated power lines 165*a*–165*f* are fed into a power input for each corresponding access point 110 through a filter 175. The filter 175 is used to remove any line noise, interference or ripple effect which commonly occur in power transmission. Although not shown, a similar DC power line can be provided to the wireless access point(s) 130 for providing operating power thereto.

The remote power source 160 preferably is located at a central location such as in a utility room, closet, computer room, etc. at a building or site in which the system 100 is located. The remote power source includes a power cable 210 which is plugged into a 110-volt AC line source such as a conventional AC power outlet. The AC power from the line

source is converted by the remote power source **160** into DC power output which is output on DC power lines **165***a*–**165***f*.

Each of the DC power lines **165***a*–**165***f* need only carry low voltage, low current power (e.g., 24 volts at 2.3 amperes) to provide for operation of the access points. Consequently, each DC power line **165***a*–**165***f* can be an inexpensive two-conductor wire such as 18-gauge, plenum rated shielded cable or even conventional zip cord. The plenum rating is preferred as it allows the power lines **165***a*–**165***f* to extend above ceiling tiles and in other locations while still meeting UL approved fire ratings. Because of the relatively low power levels associated with each DC power line **165***a*–**165***f*, there is no need for the DC power lines **165***a*–**165***f* to be enclosed in conduit in order to meet electrical code. Furthermore, because the two-conductor wire is generally flexible and easy to work with in much the same manner as the cable making up the system backbone **120**, it is quite easy to route the power lines **165***a*–**165***f* along the same run as the system backbone **120**. Hence, installation is simplified and does not require the work of a licensed electrician.

According to the present invention, the access points **110***a*–**110***f*, **130** need not include an AC/DC converter since DC power is provided directly to a power input of the access points which operate on DC power. In the exemplary embodiment, the access points **110***a*–**110***f* are designed to operate based on a 24 volt DC supply and hence the power on the respective DC power line is at 24 volts. In an alternative embodiment, however, a DC-to-DC voltage converter can be included in the access point **110** to transform the DC voltage provided on the respective DC power line **165** to the appropriate DC level required by the access point **110** for operation.

Referring now to FIG. **2**, the remote power source **160** of the present invention is shown in more detail. As is shown, the remote power source **160** includes a multiple AC outlet power strip **205** which is supplied with standard 110 volt AC power (110 VAC) through the cable **210**. The end of the cable **210** is connected to a standard wall outlet, an uninterruptable power supply, or other power source. The power strip **205** provides 110 VAC power from each of the respective outlets to each of four AC/DC converters **235***a*–**235***d* via power cords **238***a*–**238***d*, respectively. Each of the AC/DC converters **235***a*–**235***d* is used to convert the standard 110 VAC power provided from the respective power cord into 24 volts DC (24 VDC) power at 2.3 amps. The DC power output from each converter **235***a*–**235***d* is provided on lines **240***a*–**240***d*, respectively. As is discussed in more detail below in relation to FIG. 3, the AC/DC converters **235***a*–**235***c* are considered to be the primary transformers and are each capable of supplying sufficient DC operating power to two access points **110**, while the AC/DC converter **235***d* is reserved as a backup power source in the event of a failure of one or more of the primary converters **235***a*–**235***c*.

Continuing to refer to FIG. 2, the output of each AC/DC converter on lines **240***a*–**240***d* is coupled to a respective input of a power control section **260** via a corresponding connector **262***a*–**262***d* (see FIG. 3). The power control section **260** contains power control circuitry for monitoring and selecting the outputs of the respective converters **235***a*–**235***d* as is discussed in more detail below with respect to FIG. 3. The power control section **260** preferably includes a housing **264** which has several apertures through which "power side" light emitting diodes (LEDs) **265***a*–**265***d* (collectively labeled **265**) and "remote side" LEDs **268***a*–**268***f* (collectively labelled **268**) protrude such that they are visible to a user. Also visibly situated in the housing **264** is an alarm LED **270**. The alarm LED **270** illuminates instances where power supplied from any of the primary AC/DC converters **235***a*–**235***c* drops below a threshold output level. Further, an alarm silencer button **275** is also situated in the housing **264** to allow a user to turn off a warning buzzer **365** which is tripped in conjunction with the alarm LED **270**. The dedicated DC power lines **165***a*–**165***f* are connected to the output of the power control section **260** and, each line is connected directly to a power input of a corresponding access point **110** as discussed above in relation to FIG. 1.

Referring now to FIG. **3**, a more detailed diagram of the power control section **260** is shown. The output of each primary AC/DC converter **235***a*–**235***c* is coupled via the connectors **262***a*–**262***c* to an input of a corresponding compare and select circuit **330***a*–**330***c*, respectively. Additionally, the power side LEDs **265***a*–**265***c* are each coupled to the outputs **240***a*–**240***c*, respectively, via the connectors **262***a*–**262***c*. The LEDs **265***a*–**265***c* are configured so as to indicate whether a minimum threshold voltage (i.e. 6 VDC) is currently available through the associated output lines **240***a*–**240***c*. More particularly, if power is available on the output line the LEDs **265***a*–**265***c* will illuminate in green, while if the voltage on the respective output line falls below 6 VDC the respective LED will turn off. Note that in the event any particular converter **235***a*–**235***d* fails, it may be disconnected from its respective connector **262***a*–**262***d* and replaced eventually with a new converter.

The backup AC/DC converter **235***d* is provided in the remote power source **160** in the event of a failure of one or more of the primary AC/DC converters **235***a*–**235***c*. More specifically, the output of the AC/DC converter **235***d* is connected in parallel to a second input of each of the compare and select circuits **330***a*–**330***c* via the connector **262***d*. Utilizing the voltage level supplied on line **240***d* (or a predetermined fraction thereof) as the threshold level, each of the compare and select circuits **330***a*–**330***c* compares the output voltage of the corresponding primary AC/DC converter **235***a*–**235***c* with the voltage on line **240***d* to determine whether the primary AC/DC converter is supplying sufficient power to operate the access points **110** associated therewith.

In the event the output voltage from the primary AC/DC converter **235***a*–**235***c* is equal to or greater than the voltage provided by the backup AC/DC converter **235***d* (or a predetermined fraction thereof), each compare and select circuit **330***a*–**330***c* is designed to output power from the respective primary AC/DC converter onto a corresponding output line **332***a*–**332***c* of the compare and select circuit **330***a*–**330***c*. On the other hand, if the output voltage from the corresponding primary AC/DC converter is less than the voltage provided by the backup AC/DC converter **235***d* (or a predetermined fraction thereof), each compare and select circuit **330***a*–**330***c* is designed to output power from the backup AC/DC converter **235***d*, onto corresponding output line **332***a*–**332***c*. Thus, if one of the primary AC/DC converters **235***a*–**235***c* fails the corresponding compare and select circuit **330***a*–**330***c* will automatically switch over to power provided by the backup AC/DC converter **235***d* and provide such power as an output on corresponding output line **332***a*–**332***c*. If more than one primary AC/DC converter **235***a*–**235***c* fails, the power available from the backup AC/DC converter **235***d* is distributed among the outputs of the compare and select circuits **330***a*–**330***c* corresponding to each of the failed primary AC/DC converters. For this reason, it is desirable that the backup AC/DC converter **235***d*

have a power rating which is three times that of the converters 235a–235c.

As is discussed in more detail below, the power on each of the output lines 332a–332c is utilized to power a corresponding pair of access points **110**. In the exemplary embodiment each output line 332a–332c is used to feed power to two access points connected in parallel, although it will be appreciated that virtually any other number of access points can be powered by a respective output line. The primary constraints as to the number of access points per output line is the power rating of the respective AC/DC converters.

Also coupled to each of the compare and select circuits 330a–330c is an alarm circuit **335**. The alarm circuit **335** is used to provide both audio and visual indicators to a system operator in the event any of the primary AC/DC converters 235a–235c has an output power level which falls below the threshold represented by the output of the backup AC/DC converter 235d. More particularly, the compare and select circuits 330a–330c each provide a digital signal on lines 337a–337c, respectively, representing the result of the comparison between the power from the corresponding primary AC/DC converter 235a–235c and the backup threshold voltage provided by the backup AC/DC converter 235d. For example, the digital signals on lines 337a–337c change to an active level in the event the power from the backup AC/DC converter 235d exceeds that of the corresponding primary AC/DC converter. Each of lines 337a–337c is coupled to respective inputs of a monitoring circuit **355** which determines whether any of lines 337a–337c goes active indicating that backup power is needed. In the event backup power is needed by any of the primary AC/DC converters 235a–235c, the monitoring circuit **355** produces an output on line **357** which illuminates the alarm LED **270**. Further, an alarm buzzer **365**, coupled to the monitoring circuit **355**, also is sounded via the monitoring circuit **355**. The alarm LED **270** is configured to remain activated until backup power is no longer necessary. The alarm buzzer **365**, however, is designed such that it may be reset at any time by depressing the silencer button **275** which is coupled to the monitoring circuit **355**.

As shown in FIG. 3, each output line 332a–332c is split to supply power in parallel to two power connectors among power connectors 380a–380f. Each power connector 380a–380f includes positive (+) and negative (–) terminals for providing power from the corresponding output line 332a–332c to a corresponding one of the dedicated DC power lines 165a–165f connected thereto. In the exemplary embodiment, the power on output line 332a is coupled to DC power lines 165a and 165b via connectors 380a and 380b, respectively. Similarly, the power on output line 332b is coupled to DC power lines 165c and 165d via connectors 380c and 380d, respectively. Finally, the power on output line 332c is coupled to DC power lines 165e and 165f via connectors 380e and 380f, respectively. Based on the power requirements of the access points connected at the other ends of the DC power lines 165a–165f and the power rating of the AC/DC converters 235a–235d, the number of power terminals **380** supplied by each line **332** can vary as will be appreciated.

In order to protect against current surges and against fire hazards, circuit breakers 385a–385f are introduced between the output lines 332a–332c and each of the power connectors 380a–380f. Also coupled to the output of each circuit breaker **385** are the remote side LEDs 280a–280f. The remote side LEDs 280a–280f are configured to indicate whether the corresponding power connector 380a–380f is receiving power to operate an access point **110** connected thereto via the DC power line **165**. As discussed above, it is possible, for instance, that one or more of the primary AC/DC converters 235a–235c has failed while power connectors 380a–380f still provide adequate power output due to the operation of the backup AC/DC converter 235d. Therefore, it is possible that all LEDs 280a–280f will remain illuminated even though one or more primary AC/DC converters have failed. The LEDs 280a–280f in combination with the LEDs 265a–265d provide a clear visual indication of such occurrence.

Accordingly, the present invention provides for a cellular communication system which is not hampered by the aforementioned high costs and difficulties associated with providing AC electrical power to each access point. Instead, the remote power source transforms AC power to DC power at a remote location, and provides as its output one or more low voltage DC power lines. By performing the AC/DC power transformation at a central location, only low voltage DC power lines need to be fed to each access point. Thus, the need and expense for strict adherence to local electrical codes and licensed electricians is avoided. Furthermore, the backup power supply and alarm avoid unnecessary shut down of the system and draw attention to malfunctioning connections.

Although the invention has been shown and described with respect to certain preferred embodiments, it is obvious that equivalents and modifications will occur to others skilled in the art upon the reading and understanding of the specification. For example, the exemplary embodiment has been discussed in the context of three primary AC/DC converters and one backup converter. However, it will be appreciated that various other combinations can be utilized depending on the output rating of the particular converters utilized, the power draw of the access points, the number of access points in the system, etc. In addition, each access point is provided with its own dedicated DC power line. In another embodiment two or more access points could be connected to the same DC power line in parallel as will be appreciated. The present invention includes all such equivalents and modifications, and is limited only by the scope of the following claims.

What is claimed is:

1. A cellular communication system, comprising:

a system backbone;

a host computer coupled to the system backbone;

a plurality of access points coupled to the system backbone and distributed at different physical locations;

at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points; and

a remote power source for providing DC power to the plurality of access points, the remote power source being located remotely from at least one of the plurality of access points and including:

an AC/DC converter for converting AC power to DC power and for providing the DC power at an output, wherein the AC/DC converter comprises a primary AC/DC converter for providing the DC power at the output and a backup AC/DC converter for providing the DC power at the output in the event of an operational failure of the primary AC/DC converter; and

at least one DC power line extending between the output of the AC/DC converter and respective power inputs of the plurality of access points.

2. The system of claim 1, wherein the remote power source includes separate DC power lines between the output of the AC/DC converter and each of the plurality of access points.

3. The system of claim 1, wherein the at least one DC power line comprises a plenum rated shielded cable.

4. The system of claim 1, wherein the remote power source includes a visual display for indicating provision of the DC power to the at least one DC power line.

5. The system of claim 1, wherein the at least one DC power line is substantially unencumbered by conduit.

6. The system of claim 1, wherein the at least one DC power line shares a common run with the system backbone.

7. The system of claim 1, wherein the at least one mobile device comprises a mobile terminal.

8. A cellular communication system, comprising:

a system backbone;

a host computer coupled to the system backbone;

a plurality of access points coupled to the system backbone and distributed at different physical locations;

at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points; and

a remote power source for providing exclusively DC power to the plurality of access points, the remote power source being located remotely from at least one of the plurality of access points and including:

an AC/DC converter for converting AC power to DC power and for providing the DC power at an output, wherein the AC/DC converter comprises a primary AC/DC converter for providing the DC power at the output and a backup AC/DC converter for providing the DC power at the output in the event of an operational failure of the primary AC/DC converter; and

at least one DC power line extending between the output of the AC/DC converter and respective power inputs of the plurality of access points.

9. The system of claim 8, wherein the remote power source includes a visual display for indicating the failure of the primary AC/DC converter.

10. The system of claim 8, wherein the remote power source includes an audible indicator for indicating the failure of the primary AC/DC converter.

11. A cellular communication system, comprising:

a system backbone;

a host computer coupled to the system backbone;

a plurality of access points coupled to the system backbone and distributed at different physical locations;

at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points; and

a remote power source for providing exclusively DC power to the plurality of access points, the remote power source being located remotely from at least one of the plurality of access points and including:

an AC/DC converter for converting AC power to DC power and for providing the DC power at an output, wherein the AC/DC converter includes a plurality of primary AC/DC converters for providing the DC power at the output for respective ones of the plurality of access points, and at least one backup AC/DC converter for providing at least a portion of the DC power at the output in the event of an operational failure of one of the plurality of primary AC/DC converters; and

at least one DC power line extending between the output of the AC/DC converter and respective power inputs of the plurality of access points.

12. The system of claim 11, wherein the remote power source includes a compare and select circuit for each of the primary AC/DC converters with each of the compare and select circuits having as inputs the output of the corresponding primary AC/DC converter and the output of the backup AC/DC converter, and each of the compare and select circuits functioning to output selectively one of its inputs to the output of the AC/DC converter.

13. In a cellular communication system comprising a system backbone, a host computer coupled to the system backbone, a plurality of access points coupled to the system backbone and distributed at different physical locations, and at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points, a method of providing DC power to the plurality of access points comprising the steps of:

converting AC power to DC power at a location which is remote from the location of at least one of the access points and providing the DC power at an output, the converting step also including a step of using a primary AC/DC converter for providing the DC power at the output and a backup AC/DC converter for providing the DC power at the output in the event of an operational failure of the primary AC/DC converter; and

providing the DC power at the output to respective power inputs of the plurality of access points using at least one DC power line.

14. The method of claim 13, wherein the step of providing the DC power includes the step of connecting separate DC power lines between the output and each of the plurality of access points.

15. The method of claim 13, wherein the at least one DC power line comprises a plenum rated shielded cable.

16. In a cellular communication system comprising a system backbone, a host computer coupled to the system backbone, a plurality of access points coupled to the system backbone and distributed at different physical locations, and at least one mobile device for communicating on the system backbone via wireless communications with an access point selected among the plurality of access points, a method of providing power to the plurality of access points comprising the steps of:

converting AC power to DC power at a location which is remote from the location of at least one of the access points and providing the DC power at an output, the converting step also including a step of using a primary AC/DC converter for providing the DC power at the output and a backup AC/DC converter for providing the DC power at the output in the event of an operational failure of the primary AC/DC converter; and

providing the DC power at the output to respective power inputs of the plurality of access points using at least one DC power line.

17. The method of claim 16, wherein the at least one DC power line is substantially unencumbered by conduit.

18. The method of claim 16, wherein the at least one DC power line shares a common run with the system backbone.

19. The method of claim 16, wherein the at least one mobile device comprises a mobile terminal.

* * * * *

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United States Patent [19]

Fisher et al.

[11] Patent Number: 6,140,911

[45] Date of Patent: Oct. 31, 2000

[54] **POWER TRANSFER APPARATUS FOR CONCURRENTLY TRANSMITTING DATA AND POWER OVER DATA WIRES**

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[21] Appl. No.: **09/416,067**

[22] Filed: **Oct. 12, 1999**

Related U.S. Application Data

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[51] **Int. Cl.**^{7} **H04B 1/00**; G08C 19/00

[52] **U.S. Cl.** **340/310.01**; 340/310.02; 340/310.08; 340/825.72; 375/257; 375/259; 455/3.1; 455/3.3

[58] **Field of Search** 340/310.01, 310.02, 340/310.08, 825.72; 455/3.1, 3.3; 370/487, 490, 419, 442; 375/257, 259; 307/126, 128, 127

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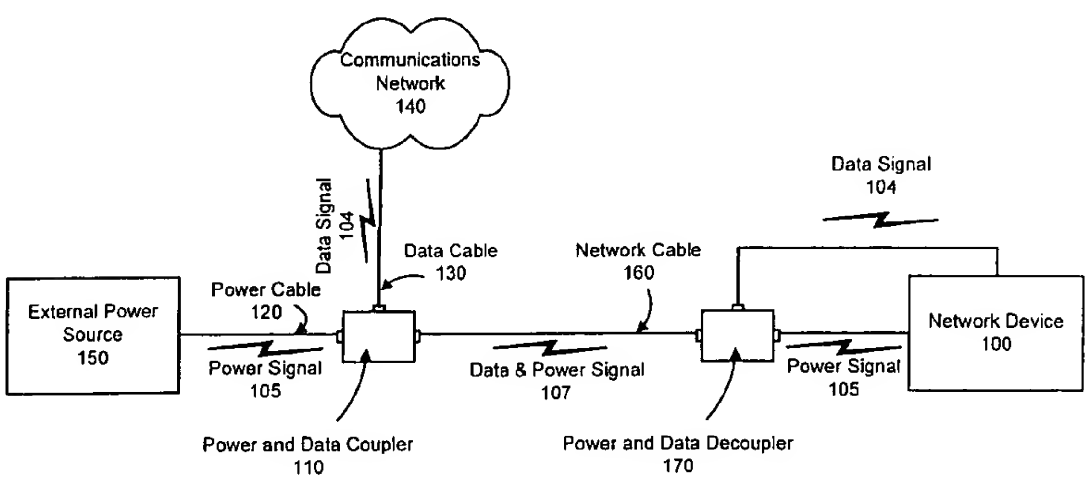
Primary Examiner—Donnie L. Crosland

Attorney, Agent, or Firm—Wilson Sonsini Goodrich & Rosati

[57] **ABSTRACT**

Electrical supply current, sufficient to power a wireless access point, is transmitted concurrently with a network data signal across a transmission line. A power and data coupler couples the network data signal and the power signal, received through a data input and a power input respectively, and transmits the coupled signal, to a distance of three meters or more, over the transmission line to a power and data decoupler. The power and data decoupler separates the power signal from the network data signal and supplies those signals to a power output port and a data output port, respectively, for use by a wireless access node. The power signal may be modulated at a low frequency relative to the frequency of the data signal, and the network data signal has a data transmission rate of one megabit/second or higher.

10 Claims, 5 Drawing Sheets



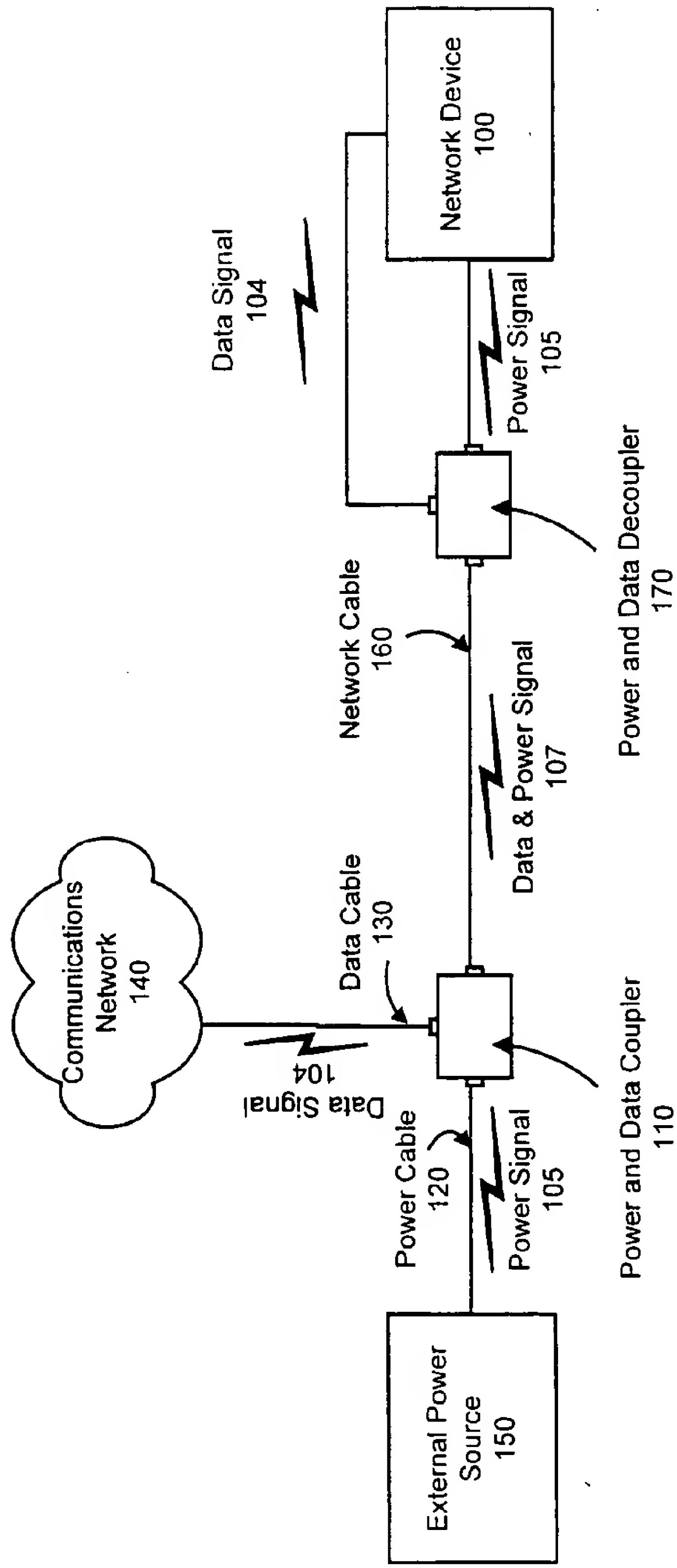
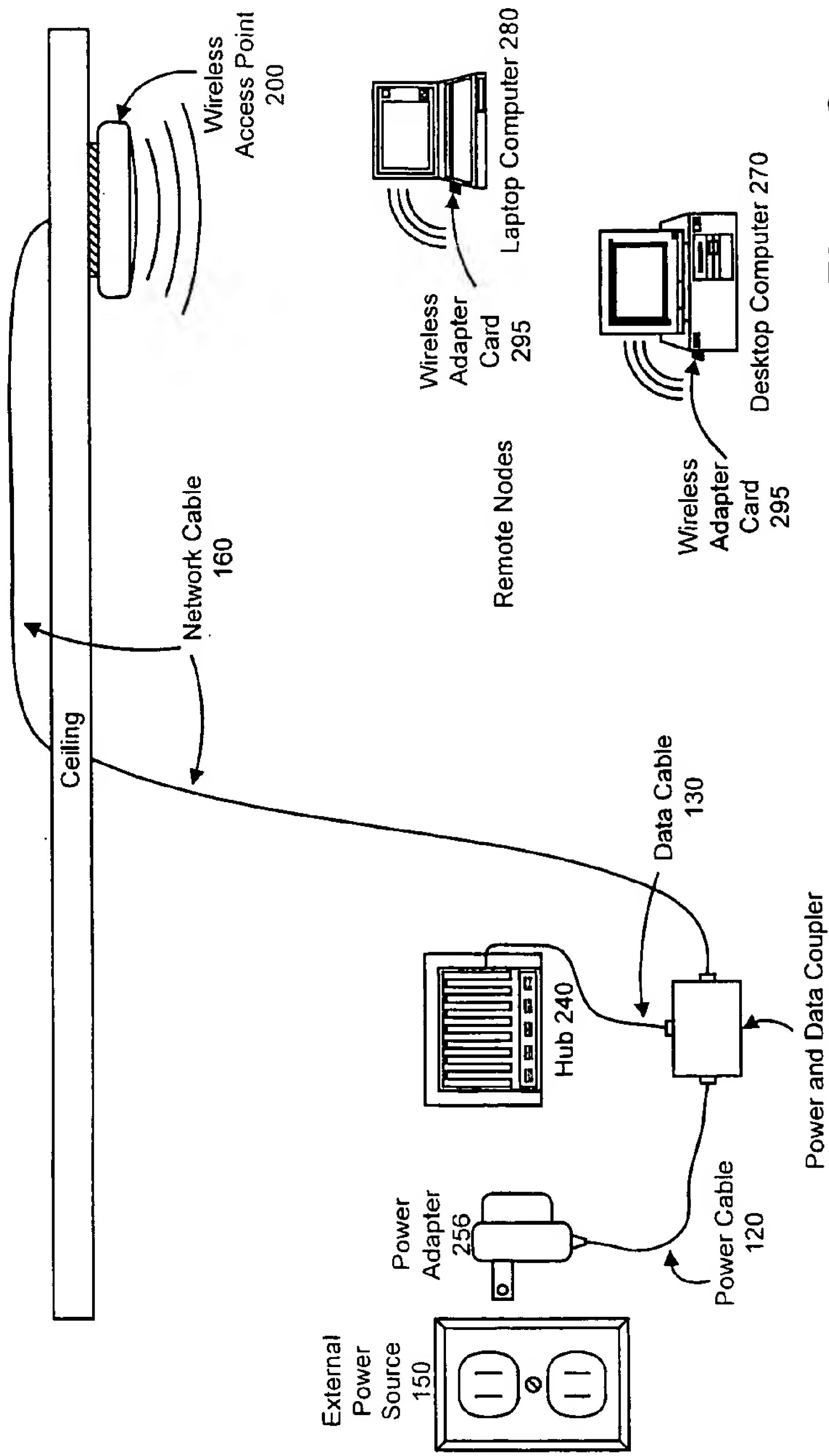

Network Device
100
Data Signal
104
Power Signal
105
Power and Data Decoupler
170
Network Cable
160
Data & Power Signal
107
Communications
Network
140
Data Cable
130
Data Signal
104
Power Cable
120
Power Signal
105
Power and Data Coupler
110
External Power
Source
150

Figure 1



Wireless Access Point 200
Laptop Computer 280
Wireless Adapter Card 295
Desktop Computer 270
Wireless Adapter Card 295
Remote Nodes
Network Cable 160
Ceiling
Data Cable 130
Hub 240
Power and Data Coupler 110
Power Adapter 256
Power Cable 120
External Power Source 150

Figure 2

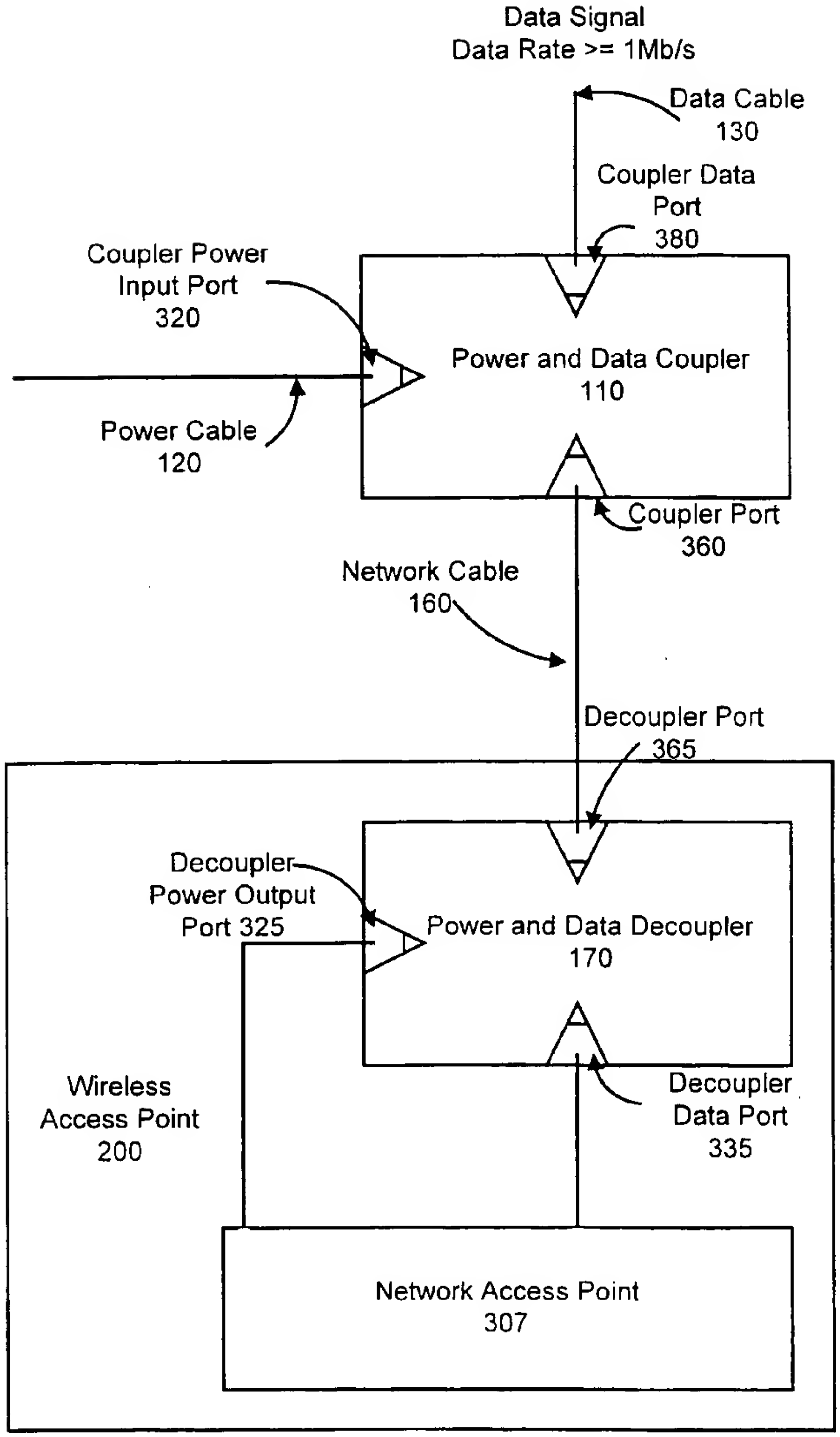

Data Signal
Data Rate >= 1Mb/s
Data Cable
130
Coupler Data
Port
380
Coupler Power
Input Port
320
Power and Data Coupler
110
Power Cable
120
Coupler Port
360
Network Cable
160
Decoupler Port
365
Decoupler
Power Output
Port 325
Power and Data Decoupler
170
Wireless
Access Point
200
Decoupler
Data Port
335
Network Access Point
307

Figure 3

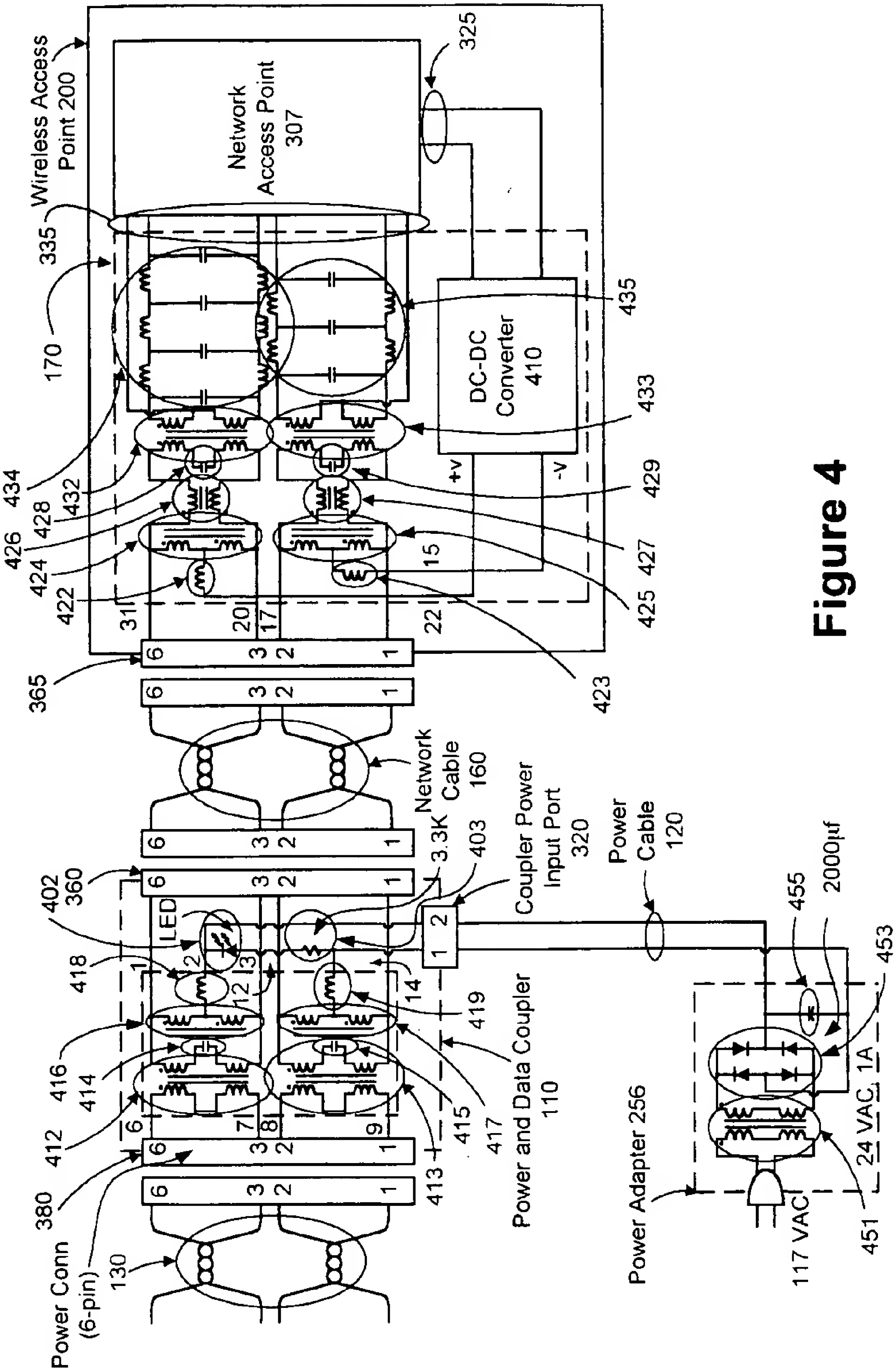
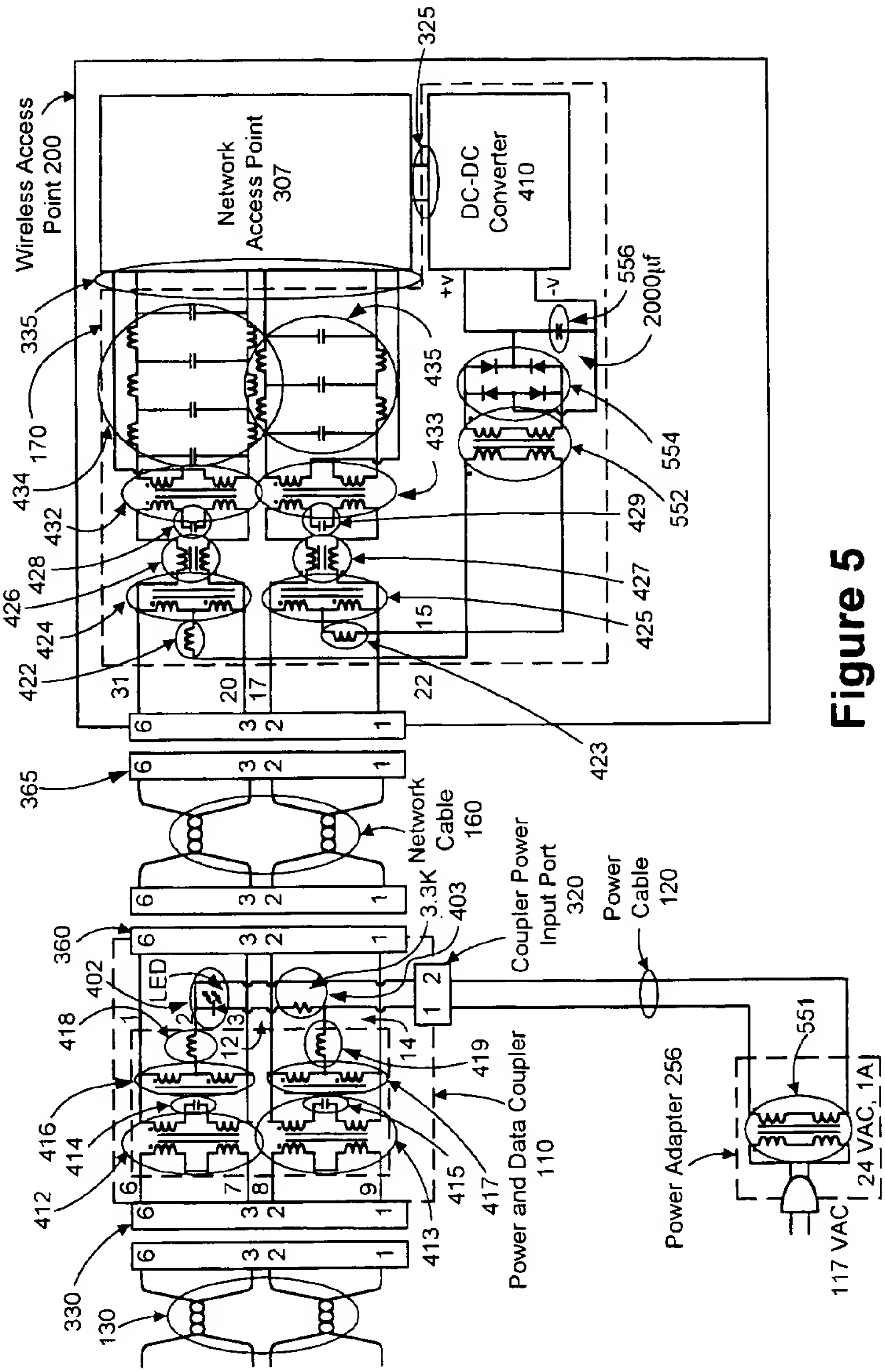

Wireless Access Point 200
Network Access Point 307
325
335
170
435
DC-DC Converter 410
433
434
432
428
426
424
422
429
427
425
423
+v
-v
15
31
20
17
22
365
Network Cable 160
3.3K
403
Coupler Power Input Port 320
Power Cable 120
402
360
LED
418
416
414
412
413
415
417
419
Power and Data Coupler 110
380
Power Conn (6-pin)
130
Power Adapter 256
117 VAC
451
24 VAC, 1A
453
455
2000µf

Figure 4



Wireless Access Point 200
Network Access Point 307
DC-DC Converter 410
325
335
170
434
432
428
426
424
422
31
20
17
22
15
435
433
429
427
425
423
556
2000µf
554
552
+v
-v
365
Network Cable 160
3.3K
403
360
402
LED
418
416
414
412
330
130
413
415
417
419
Power and Data Coupler 110
Coupler Power Input Port 320
Power Cable 120
Power Adapter 256
551
24 VAC, 1A
117 VAC

Figure 5

POWER TRANSFER APPARATUS FOR CONCURRENTLY TRANSMITTING DATA AND POWER OVER DATA WIRES

RELATIONSHIP TO COPENDING APPLICATIONS

This application is a Continuation of application Ser. No. 08/865,016, filed May 29, 1997, now U.S. Pat. No. 5,994, 998 which is incorporated herein by reference in its entirety.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to the field of data networking and communications, and in particular to interconnecting computers to a local area network ("LAN") or a wide area network ("WAN") through data lines that also carry power.

2. Description of the Related Art

Network devices typically communicate via wired data lines and receive power from a separate line. For example, personal computers ("PCs") may communicate ethernet signals via category three (CAT-3) or category five (CAT-5) twisted pair wire and receive power from a second cable connected to a power source, such as a wall socket or a battery. However, it is desirable to be able to eliminate the need for the second cable. The following describes examples of network devices that benefit from the elimination of the separate power line, and then describes some of the inadequacies of previous solutions.

Plain old telephone service ("POTS") combines a voice signal with a power signal. The combined signal is transmitted over twisted pair cable between the telephone and the line card at the public telephone exchange office. The line card also supplies power over the two wires carrying the voice signal. However, the voice signal supported by POTS is not sufficient for bandwidth intensive communications needs, such as, ethernet communications. Similarly, ISDN communications transmit power and digital data over between an ISDN modem and a telephone switch. However, ISDN data rates are more than an order of magnitude lower than ethernet data rates.

Wireless network adapters can interconnect PCs, or other networked device. The wireless network adaptors use, for example, infrared (IR) or radio frequency (RF) modulation to transmit data between wireless access points and the wireless adaptors connected to PCs. Although the wireless adaptors and wireless access points may be more expensive than comparable wired equipment, they provide savings in wiring costs and permit greater flexibility by allowing the PCs to be moved to any location within the range of the system without the necessity of rewiring the building.

Typically, a transceiver (meaning transmitter and receiver) called a wireless access point, mounted at an elevated location, such as on a ceiling or high on a wall, provides network data communications between a network hub, switch, router or server, to all the PCs located in that room which are equipped with a compatible wireless networking adaptor. The wireless access point is an active electronic device that requires a communications link to a hub or server as well as electrical power to operate. Both the data signal and power signal must be provided to the wireless access point. The data signal is typically at a lower voltage than the power signal, but at a significantly higher frequency, sufficient to sustain a high data transfer rate (e.g., 100 kilobits per second or higher). The available power is

usually 110V or 220V AC at frequencies below one hundred Hz. Often two separate sets of wires are used to carry the data signal and power signal. One set of wires is used to couple the wireless access point and the hub and the other set of wires is used to couple the wireless access point to the power outlet.

Eliminating the need for separate power and data wiring simplifies the installation of a wireless access point and can reduce the cost of the installation. Therefore, it is desirable to transmit sufficient electrical power to operate the wireless access point through the network cable that is used to connect the wireless access point to the hub or server.

One possible solution is to transmit power on the unused wires of the data cable. An example of this approach can be found in the VIPSLAN-10™ product manufactured by the JVC Information Products Company of Irvine, Calif. Of course this requires that additional, unused wire pairs be available in the data cable, which may not always be available. Also, if a change in the networking standard in the future dictates the use of the currently unused wire pairs in the networking cable, this solution becomes difficult to implement.

Therefore, what is needed is a solution that reduces the wiring requirements to transmit data and power to a wireless access point without having to use additional wire pairs.

SUMMARY OF THE INVENTION

One embodiment of the invention includes an apparatus for providing electric power supply current to a network device across a transmission line. A power and data coupler ("the coupler") is coupled to one end of the transmission line. The transmission line is also adapted for transmission of a data signal. The coupler has a data input and a power input. Power supply current from the power input is coupled to data signal from the data input and the combined power supply current and data signal is coupled to one end of the transmission line. The opposite end of the transmission line is coupled to a power and data decoupler ("the decoupler"). The decoupler has a power output and a data output. Both the data output and power output of the decoupler are coupled to the network device. The combined power supply current and data signal is decoupled by the decoupler, and the data signal is supplied to the data output and the power supply current is supplied to the power output. Thus, the data signal and the power supply current are coupled and transmitted via the transmission line from the coupler to the decoupler and then decoupled and provided separately to the network device.

In another embodiment, the transmission line includes two transmission lines. One of the transmission lines carries both data and power signals.

In other embodiments, the power signal includes alternating current and/or direct current.

In another embodiment, the transmission lines include twisted pair cables.

In other embodiments, the network devices include wireless access points, network interface cards, peripheral devices and/or network computers.

These features of the invention will be apparent from the following description which should be read in light of the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is an overview of an installation of a power transfer apparatus.

FIG. 2 is an overview of a power transfer apparatus for use with wireless access points.

FIG. 3 is a schematic diagram of a power transfer apparatus.

FIG. 4 is a more detailed schematic drawing showing a DC power transfer apparatus and corresponding circuitry located in the wireless access point.

FIG. 5 is a more detailed schematic drawing showing an AC power transfer apparatus and corresponding circuitry located in the wireless access. This apparatus provides electrical isolation to the wireless access point.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The following describes multiple embodiments of the invention. In one embodiment, power and data are combined and transmitted to a network device such as a wireless access point. The wireless access point uses the power signal to power communication circuits for communicating with wireless network nodes. Because the power and data are combined, the installation of the wireless access point is simplified and may reduce the cost of installing the wireless access points.

Power Transfer Apparatus Overview

FIG. 1 shows the overall configuration of one embodiment of the invention including a power transfer apparatus. The following lists the elements in FIG. 1 and then describes those elements.

FIG. 1 includes the following elements: an external power source **150**; a power cable **120**; a data cable **130**; a power and data coupler **110**; a network cable **160**; a power and data decoupler **170**; and, a network device **100**.

The following describes the coupling of the elements of FIG. 1. The external power source **150** couples to the power and data coupler **110** via the power cable **120**. The power cable **120** couples to the power and data coupler **110**. The communications network **140** couples to the data cable **130**. The data cable **130** couples to the power and data coupler **110**. The power and data coupler **110** also couples to the network cable **160**. The network cable **160** couples to the power and data decoupler **170**. The power and data decoupler **170** couples to the network device **100**.

The following describes the elements in greater detail and then describes how the elements act together.

The external power source **150** provides a power signal **105** to the power and data coupler **110**. Various embodiments of the invention use different external power sources **150**: such as, a computer's power supply, a battery, or a wall outlet and adaptor. What is important, however, is that there is some source of power that can eventually be supplied to the network device **100**.

In one embodiment, the power cable **120** is a standard two wire power cable. Other embodiments use other power transfer apparatuses to provide power to the power and data coupler **110**.

The communications network **140** is representative of many different types of communications networks supported by various embodiments of the invention. Example communications networks **140** include FDDI, ethernet (including ten Mbits/s, one hundred Mbits/s, and one gigibits/s standards), ATM, token ring, and AppleTalk. However, what is important is that a data signal **104** is communicated between the communication network **140** and the network device **100**.

The power and data coupler **110** couples the power signal **105** with the data signal **104** to produce a combined power and data signal **107**. The power and data coupler **110** is described in greater detail below. What is important is that there is some combined power and data signal **107** that can eventually be supplied to the network device **100**.

The network cable **160** includes one or more wires for transmitting the combined power and data signal **107**. In one embodiment, the network cable **160** includes an CAT-3, CAT-5 twisted pair cable, or coaxial cable.

The network device **100** represents a class of devices supported by various embodiments of the invention. For example, in one embodiment, the network device **100** includes a wireless access point. In another embodiment, the network device **100** includes a personal computer having a network interface card. In another embodiment, the network device **100** includes a network computer.

The following describes the general operation of the elements of FIG. 1. A data signal is communicated to the power and data coupler **110** via the data cable **130** from a communications network **140**. The combined power and data signal **107** is transmitted over the network cable **160** to the network device **100**. In this embodiment, the network cable **160** is longer than three meters and the combined power and data signal **107** communicates data at greater than one megabit/second. (In another embodiment, the network cable length conforms to the IEEE 802.3 specification.) Thus, the power and data coupler **110** supplies both power and data to the network device **100**. The network device **100** uses the power to operate which includes receiving, processing, and generating the data signal.

Wireless Access Point Having a Power Transfer Apparatus

FIG. 2 is an overview of a power transfer apparatus for use with wireless access points. The following lists the elements in FIG. 2 and then describes those elements. FIG. 2 includes: an external power source **150**, a power adaptor **256**, a power cable **120**, a hub **240**, a data cable **130**, a power and data coupler **110**, a network cable **160**, a wireless access point **200**, and a number of remote nodes. The remote nodes include laptop computers **280** and a desktop computer **270**. Each computer includes a wireless adaptor card **295**.

The power adaptor **256** steps down available electrical power from 117 or 220 volts AC to an AC or DC voltage that is high enough to provide adequate voltage for the wireless access point **200**. In one embodiment, the power adaptor **256** supplies an output voltage of approximately twenty-four volts. Other embodiments of the invention have other output voltages, such as thirty-six and forty-eight volts. The power adaptor **256** is described in greater detail in the description of FIG. **5**.

The hub **240** is not needed in one embodiment of the invention to supply the data signal. Therefore, in other embodiments of the invention, the data signal is supplied by a network computer, a router, and a bridge. In one embodiment, the hub **240** provides an ethernet based data signal supporting a data transfer rate of at least one megabit/second.

Regarding the power and data coupler **110**, what is important is that there is some combined power and data signal **107** that can eventually be supplied to the wireless access point **200**. Therefore, for example, in one embodiment, the power and data coupler **110** is included in a network card in the hub **240**. The power signal **105**, taken from the hub's power supply, can then be combined with the data signal provided by the hub **240**.

The wireless access point **200** is an example of a network device **100**. The wireless access point **200** includes a trans-

ceiver for providing wireless communications with the wireless adaptor cards 295. In this example, the wireless access point 200 is mounted on the ceiling. The wireless access point 200 is described in greater detail below.

The wireless adaptor cards 295 also include a transceiver for communicating with the wireless access point 200.

The desktop computer 270 and the laptop computer 280 are examples of some devices that may be included in one embodiment of the invention. For example, the desktop computer 270 can include an IBM compatible personal computer, or a MacOS™ compatible computer. However, other embodiments of the invention include other remote network nodes such as a Newton™ personal digital assistant and a pager.

The following describes the general operating of the system shown in FIG. 2. The power adapter 256 supplies power to the power and data coupler 110 while the hub 240 provides a data signal to the power and data coupler 110. The power and data coupler 110 communicates a combined power and data signal 107 to the wireless access point 200. The wireless access point 200 is powered from the power part of the power and data signal 107. The wireless access point 200 communicates a wireless data signal with the wireless adapter cards 295. The wireless data signal corresponds to the data signal from the hub 240. The wireless adapter cards 295 provide the desktop computer 270 and the laptop computers 280 with the wireless data signal.

Schematic Diagram of a Power Transfer Apparatus

FIG. 3 is a schematic diagram of a power transfer apparatus. The following first lists the elements in FIG. 3, then describes the elements' couplings, and then describes the elements' interactions.

FIG. 3 includes: the power cable 120, the data cable 130, power and data coupler 110, the network cable 160, and the wireless access point 200. The power and data coupler 110 includes a coupler power input port 320, a coupler data port 380 and a coupler port 360. The wireless access point 200 includes a power and data decoupler 170 and a network access point 307. The power and data decoupler 170 includes a decoupler port 365, a decoupler power output port 325 and a decoupler data port 335.

The elements of FIG. 3 are coupled as follows. The power cable 120 is coupled to the coupler power input port 320. The data cable 130 is coupled to the coupler data port 380. The network cable 160 is coupled to the coupler port 360 and to the decoupler port 365. The wireless access point 200 is coupled to the decoupler power output port 325 and to the decoupler data port 335.

The power and data decoupler 170 performs a function similar to that performed by the power and data coupler 110. However, the power and data decoupler 170 decouples the power signal from the data signal. The power and data decoupler 170 can then supply the power signal to the network access point 307 separately from the data signal.

The network access point 307 includes the transceiver for communicating with the remote nodes.

The elements of FIG. 3 interact as follows. The power cable 120 provides power supply current to the coupler power input port 320. The data cable 130 transmits the network data signal to the coupler data port 380. The power and data coupler 110 combines the power signal and the data signal and outputs this signal at the coupler port 360. The combined power and data signal is transmitted on the network cable 160. The wireless access point 200 receives the combined power and data signal through the decoupler port 365. The power and data decoupler 170 separates the network data signal from the power supply current. The power and data decoupler 170 then supplies the power signal at the decoupler power output port 325 and communicates the data signal to the network access point 307 at the decoupler data port 335. The network access point 307 uses the power signal to power wireless data signals to the remote nodes. The wireless data signals correspond to the data signal communicated with the decoupler data port 335.

In another embodiment of the invention, separate transmit and receive paths are supported between the power and data coupler 110 and the power and data decoupler 170. In this embodiment, the data cable 130 includes at least two wires supporting a transmit path and two wires supporting a receive path. Note that power is only coupled to the transmit path wires in one embodiment. While in another embodiment, all four wires are used in the power transmission.

FIG. 4 shows a more detailed schematic of one configuration of this invention. The example shown in FIG. 4 is specifically adapted for the 10Base-T twisted pair networking protocol. Other embodiments of the invention support other network protocols. These embodiments include modifications for the number of wires used by the particular network protocol. The following lists the elements of FIG. 4, describes their interconnections, and then describes the operation of the elements.

FIG. 4 includes: the power adapter 256, the power cable 120, the data cable 130, the network cable 160 and the wireless access point 200. The power adapter 256 includes a step-down transformer 451, a diode bridge 453, and a capacitor 455. The power and data coupler 110 includes: the coupler data port 380, a pair of isolation transformers (isolation transformer 412 and isolation transformer 413), a pair of center tapped inductors (inductor 416 and inductor 417), a pair of capacitors (capacitor 414 and capacitor 415), a pair of inductors (inductor 418 and inductor 419), a light emitting diode (LED 402), a resistor 403, and the coupler power and data port 360. The wireless access point 200 includes the network access point 307 and the power and data decoupler 170. The power and data decoupler 170 includes: the decoupler power and data port 365, a pair of inductors (inductor 422 and inductor 423), a pair or center tapped inductors (inductor 524 and inductor 425), a pair of common mode chokes (choke 426 and choke 427), a pair of capacitors (capacitor 428 and capacitor 429), a pair of isolation transformers (transformer 432 and transformer 433), a receive filter 434, a transmit filter 435, a DC-DC converter 410, a decoupler power output port 325, and the decoupler data port 335. In one embodiment, the lowpass filters, the common mode choke, and the transformers are all part of the wireless access point.

The elements in the power adapter 256 are coupled as follows. The primary winding of the transformer 451 is coupled to receive the power signal from the power adapter 256. The diode bridge 453 is connected to the secondary winding of the transformer 451. The capacitor 455 is connected across the output of the diode bridge 453. The output of the diode bridge 453 is connected to power cable 120.

The elements in the power and data coupler 110 are coupled as follows. In this example, the data signal is carried on four wires. Thus, the coupler data port 380 includes a four wire connection to the data cable 130. The primary windings of the transformer 412 are connected to the two data input wires of the coupler data port 380. Similarly, the primary windings of the transformer 413 are connected to the two data output wires of the coupler data port 380. The capacitor 414 and the capacitor 415 are connected in series with the secondary windings of the transformer 412 and the trans-

former 413, respectively. The center tapped inductor 416 and two output data wires of the coupler output port 360 are coupled across the secondary winding of the isolation transformer 412. Similarly, the center tapped inductor 417 and two input data wires of the coupler input port 360 are coupled across the secondary winding of the isolation transformer 413. The inductor 418 is connected between the center tap of the inductor 416 and to the positive wires of the power cable 120. The inductor 419 is connected between the center tap of the inductor 417 and the negative wires of the power cable 120. The resistor 403 and LED 402 are connected across the positive and negative wires of the power cable 120.

The elements in the wireless access point 200 are coupled as follows. The center tapped inductor 422 and the center tapped inductor 423 connect across the two input wires and two output wires, respectively, of the decoupler port 365. The inductor 422 connects to the center tap of the center tapped inductor 424 and to the positive terminal of the DC-DC converter 410. Similarly, the inductor 423 connects to the center tap of the center tapped inductor 425 and to the negative terminal of the DC-DC converter 410. The choke 426 connects to the ends of the center tapped inductor 424 and across the primary winding of the transformer 432. The choke 427 connects to the ends of the center tapped inductor 425 and across the primary winding of the transformer 433. The receive filter 434 connects between the secondary winding of the transformer 432 and the two output wires of the decoupler port 335. The transmit filter 435 connects between the secondary winding of the transformer 433 and the two input wires of the decoupler port 335. The DC-DC converter 410 connects to the decoupler power output 325.

The power adapter 256 operates as follows. Power is received from the external power supply at the primary winding of the transformer 451. The transformer 451 electrically isolates the power adapter 256. The diode bridge 453 performs fill wave rectification of the alternating current from the secondary winding of the transformer 451. The capacitor 455 helps in the full wave rectification to create a DC output. The winding ratio of the transformer 451 and the value of the capacitor 455 is selected to provide the proper voltage output given the input voltage connected to the primary of the transformer 451. The power adapter 256 is representative of a variety of commercially available power adapters.

The power and data coupler 110 operates as follows. There is one isolation transformer (e.g., transformer 412) and one center-tapped inductor (e.g., 416) for each pair of networking data wires used in the particular networking standard. The data signal passes through these transformers with minimal loss. The transformers eliminate ground loops between the power and data coupler 110 and any network devices attached to coupler data port 330. The isolation transformers also isolate the power and data coupler 110 in case of accidental contact between the data cable 130 and a high voltage source. In one embodiment, the isolation transformer 412 and the isolation transformer 413 have a winding ratio of approximately 1:1 and an isolation of one thousand five hundred volts. The capacitor 414 and the capacitor 415 remove DC current from the data signal.

Each center-tapped inductor (e.g., inductor 416) presents an impedance close to zero Ohms for DC or low frequency AC current, however, the impedance across each wire pair to the data signal is significantly higher. (The low frequency AC current is low relative to the data signal frequency. In one embodiment, the low frequency AC current is less than one hundred Hertz while the data signal is greater than one Megahertz.) The use of center-tapped inductors permits the current to flow relatively unimpeded and balanced down each wire of the wire pairs connected across the winding of each center-tapped inductor. The equal current flow reduces the line resistance to DC and permits the current to flow equally to/from each end of the center-tapped inductor. The equal flow creates an equal and opposite DC flux within the core of the center-tapped inductor, preventing the saturation of the core of the center-tapped inductor. In one embodiment of the invention, the series inductor 418 and the series inductor 419 provide additional isolation between the power signal and the high-frequency data signal. The series inductors 418 and 419 are optional in some embodiments.

The data signal connection to the data cable 130 is provided through coupler data port 330 which is selected for compatibility with the particular network protocol used. Certain data cables have wires that are not used for data communication with certain protocols. For example, the CAT-3 or CAT-5 cable has four wires that are not used with the 10BASE-T standard (i.e. two sets of pairs). The power transmission apparatus of the invention transmits the power signal using only the wires normally used for data communication. The unused wires are not used.

One embodiment of the invention includes the resister 403 and the LED 402. The LED 402 indicates whether the power signal is being received by the power and data coupler 110. Although this indication is desirable from an operational point of view, the LED 402 and resistor 403 are not required for the operation of one embodiment of the invention.

The wireless access point 200 operates as follows. The wireless access point 200 receives the combined power and data signal at the decoupler port 365. The DC, or AC power, flows through the center-tap of the center-tapped inductor 424 and the center-tapped inductor 425. The DC-DC converter 410 is preferred because of its high efficiency and low self-power dissipation (the DC-DC converter 410 allows for lower input voltages). However other devices, such as linear regulators, may be used to regulated the specific voltage and varying current loads required by the network access point 307. The series inductor 422 and the series inductor 423 enhance the isolation between the data and power lines. The common mode choke 426 and the common mode choke 427 help suppress high frequency signal components that cause electromagnetic interference with the network access point 307. The data signal is provided across the secondary windings of the isolation transformer 432 and the isolation transformer 433. The data signal being sent to the network access point 307 is then filtered using the receive filter 434. The data signal being sent from the network access point 307 is filtered before being sent out on the network cable 160. The network access point 307 can then use the power signal from the DC-DC converter 410 and communicate information to and from the remote nodes and the network using the data signal.

FIG. 5 shows an alternate embodiment of the invention. In this embodiment, the power adapter 256 has been modified so that the secondary winding of transformer 451 is directly coupled to the power cable 120. The power and data decoupler 170 includes the following new elements: a transformer 552, a diode bridge 554, and a capacitor 556. The primary winding of the transformer 552 is connected across to the inductor 422 and the inductor 423. The input of the diode bridge 554 is coupled across the secondary winding of the transformer 552 and output of the diode bridge 554 is coupled to the DC-DC converter 410. The capacitor 556 is connected across the output of diode bridge 554.

In the alternative embodiment of the invention, the power adapter **256** provides low voltage AC power, instead of DC power, to the power and data coupler **110**. The transformer **551** has a winding ratio to create low voltage AC power from the input high voltage AC power. The low voltage AC power is combined, in the same manner described above for the DC power, with the data signal. The combined power and data signal is then transmitted via network cable **160**. The low voltage AC power is separated in the power and data decoupler **170** in the same manner as described above for the DC power. The low voltage AC power is then passed through the transformer **552** and the rectifying circuit (including the diode bridge **554** and the capacitor **556**). The output of the rectifying circuit connects to the DC-DC converter **410**. This configuration provides further enhanced isolation to the data cable and any networking accessories connected to the power and data coupler **110**.

In one embodiment, the frequency of the AC power signal is substantially less than the frequency of the data signal. In various embodiments, the AC power signal has a frequency of 60 Hz, 440 Hz, and 56 Hz, while the data signal has a frequency of approximately 1 MHz, 10 MHz, and 1 GHz. However, the exact frequencies are not important, only that there is some difference between the frequencies.

The preceding has described multiple embodiments of the invention. In one embodiment, power and data are combined and transmitted to a wireless access point. The wireless access point uses the power to communicate with wireless network nodes. Because the power and data are combined, the installation of the wireless access point is simplified and may reduce the cost of installing the wireless access points.

While the foregoing invention has been described in referenced to some of its embodiments, it should be understood that various modifications and alterations will occur to those practiced in the art. Such modifications and alterations are intended to fall within the scope of the appended claims:

1. An apparatus for providing an electrical power signal and data signal to a wireless network device, comprising:

a network transmission line having a proximal end and a distal end, the distal end coupled to a wireless access point, the network transmission line adapted for transmission of a local area network data signal to the wireless access point over a distance of greater than 3 meters, the local area network data signal being transmitted at greater than 1 megabits per second:

a coupler coupled to the proximal end of the network transmission line, the coupler having a data input and a power input, the coupler couples the power signal from the power input and the local area network data signal from the data input to the network transmission line; and

a decoupler coupled to the distal end of the network transmission line, the decoupler having a data output coupled to the wireless access point and a power output coupled to the wireless access point, the decoupler supplies the local area network data signal from the network transmission line to the data output and the power signal from the network transmission line to the power output associated with the wireless access point; and

wherein the wireless access point is powered by the power signal and provides the data signal to the wireless network device that is configured to receive the data signal from the wireless access point.

2. The apparatus of claim **1**, wherein the wireless access point contains a transceiver for transmitting and receiving wireless communications between the wireless network device and the wireless access point.

3. The apparatus of claim **1**, wherein the wireless network device contains a transceiver for transmitting and receiving wireless communications between the wireless network device and the wireless access point.

4. The apparatus of claim **1**, wherein the wireless access point receives the power signal through a pair of center-tapped inductors.

5. The apparatus of claim **4**, further including a DC-DC converter configured to receive the power signal from the pair of center-tapped inductors and supply the power signal to the wireless access point.

6. The apparatus of claim **4**, further including a linear regulator configured to receive the power signal from the pair of center-tapped inductors and supply the power signal to the wireless access point.

7. The apparatus of claim **4**, further including a series inductor located between the output of each center-tapped inductor and the wireless access point.

8. The apparatus of claim **7**, wherein the series inductor operates to enhance the isolation between the power signal and the data signal.

9. The apparatus of claim **1**, wherein the wireless access point includes a pair of common mode chokes for suppressing high frequency signal components.

10. The apparatus of claim **1**, wherein the wireless access point includes a pair of isolation transformers, wherein the data signal is applied to the isolation transformers and a receive filter before being supplied to the transceiver of the wireless access point.

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